CHAPTER 4. ENVIRONMENTAL CONSEQUENCES

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ISSUES RELATED TO THE COLORADO RIVER MANAGEMENT PLAN

Issues related to the *Colorado River Management Plan* were identified through public scoping, internal scoping and tribal consultations. These issues are summarized in Chapter 1 and Appendix B. Resource-specific issues are discussed under each impact topic in the following sections of this chapter.

GUIDING REGULATIONS AND POLICIES

Overarching environmental protection laws and policies that have guided the development of this revisions of the *Colorado River Management Plan* include the National Park Service Organic Act (as amended), the National Environmental Policy Act of 1969 (including its amendments and implementing regulations), and the National Parks Omnibus Management Act of 1998. As discussed in Chapter 1, the National Park Service Organic Act authorizes rules and regulations for the use and administration of national park system areas, whose purpose is "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

The National Environmental Policy Act (NEPA) of 1969 as amended (42 USC 4321, and 4331–4335) requires federal agencies to prepare fully analyze the impacts to the environment when a major federal action is planned that could affect the quality of the human environment. The Council on Environmental Quality (CEQ) has established regulations that implement the act (40 CFR Parts 1500–1508), and the National Park Service has adopted procedures to comply with both the act and the CEQ regulations. These procedures are detailed in *Director's Order #12: Conservation Planning, Environmental Impact Analysis, and Decision-making* and its accompanying handbook*:*

The National Parks Omnibus Management Act of 1998 (PL 105-391) requires the Secretary of the Interior to continually improve the National Park Service's ability to provide state-of-the-art management, protection, and interpretation of and research on resources under its jurisdiction. Thus, park management decisions must be based on full and proper utilization of the results of scientific study. Additionally, this act states that in each case where an NPS action may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which resource studies have been considered.

Resource-specific regulations and policies are discussed for each impact topic in the following sections of this chapter.

MANAGEMENT OBJECTIVES FOR THE COLORADO RIVER MANAGEMENT PLAN

Management objectives for the of recreational use of the Colorado River as it runs through Grand Canyon National Park are discussed in Chapter 1. Management objectives for each impact topic were used to guide analysis of environmental consequences and are discussed per impact topic in the following sections of this chapter.

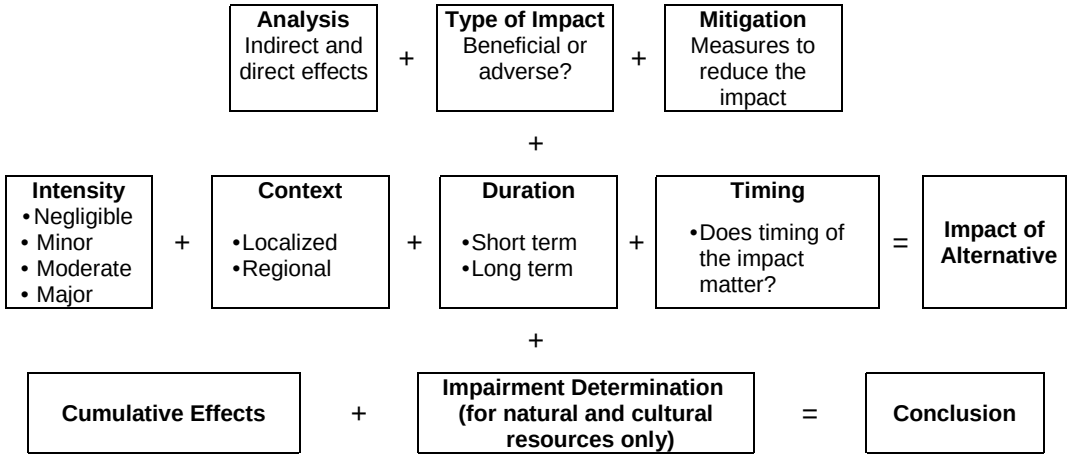
METHODOLOGY FOR ANALYZING IMPACTS

GENERAL ANALYSIS METHOD

For each impact topic described in Chapter 3 (e.g., air quality, biological resources), the following impact assessment methodology was followed:

- *Define issues of concern* — This step is based on public scoping, internal scoping and tribal consultation, for each resource topic.
- *Identify the area of potential effect* — The resources, values, and visitor experiences within an area that could be affected are identified.
- *Identify the effects of each alternative* — This was accomplished in two ways: (1) by considering the anticipated impacts of the alternatives on the baseline or existing conditions as described for the no-action alternatives (Alternatives A and 1), and (2) by comparing the anticipated impacts of the alternatives to a condition reasonably affected only by natural processes because in many cases the no-action alternatives are causing significant impacts on the canyon environment. This does not imply comparisons to some sort of idealized "pristine" condition that might have existed if humans had never affected the area at all. Rather, it is a condition that might have existed if humans had had little effect on the environment in the area, or if the impacts of the no-action alternatives were reduced to negligible for all impact topics. Effects were characterized based on the following factors (see Figure 4-1):
    - Both direct and indirect effects were considered. A direct effect is caused by an action and occurs in the same time and place. An indirect effect is caused by an action but is later in time or farther away, but is still reasonably foreseeable.
    - Whether the effects on the impact topics would be beneficial or adverse. A beneficial effect is a positive change in the condition or appearance of a resource or a change that moves the resource toward a desired condition (consistent with park purpose and management objectives). An adverse effect is a change that moves the resource away from a desired condition or detracts from its condition or appearance.
    - The intensity or magnitude of the impact. Four impact thresholds of intensity — negligible, minor, moderate, and major — are defined for each impact topic. Threshold values for these four intensity categories were developed based on federal and state standards, consultation with regulators from applicable agencies, management objectives for the revised *Colorado River Management Plan,* public scoping, tribal consultations, and discussions with subject matter experts.

FIGURE 4-1: GENERAL METHODOLOGY FOR IMPACT ANALYSIS



- The context of the impact, primarily whether impacts would be regional or localized, but also whether they would occur in a location that is sensitive or non-sensitive to such impacts. Generally, regional impacts are associated with a management zone, in this case Zone 1, 2, or 3. Localized impacts are those associated with campsites, lunch stops, and attraction sites. If definitions vary from these, they are discussed in the appropriate impact topic section.
- Whether the duration of the effect is short term or long term. Definitions of these terms vary by impact topic and are addressed in each of the following sections.
- If timing of an action contributes to impacts. The exact time when an impact would occur can often be important, including sensitive time periods, time of day, how often the impact would occur, and seasonality.

- *Identify reasonable mitigations* — Mitigating measures were considered for each impact topic to reduce, avoid, or minimize impacts under each alternative. During the alternatives development process, many mitigating measures were incorporated into the alternatives, or included as part of carrying capacity standards, or elements common to all alternatives (see Chapter 2). In all cases the most important mitigation measure is a commitment to a monitoring and implementation plan and program, as discussed in Chapter 2. During the impact analysis, additional mitigating measures were identified that would likely reduce impacts to each impact topic. A determination was made for each impact topic whether these additional measures could reduce the impacts to a minor intensity or less. Reasonable mitigations are those that could be implemented under conceivably foreseeable operating conditions and would not cause substantial adverse effects to other resources (cultural or natural resources or visitor experience).
- *Determine whether an impact constitutes impairment* — The National Park Service is prohibited from impairing park resources and values by the NPS Organic Act. The determination of impairment is closely tied to the outcome of the resource impact analysis and consideration of the park's legislative mandates (purpose and significance), and resource management objectives as defined in the *General Management Plan* or other relevant plans. The impact analysis includes any findings of impairment to park resources and

values for each of the management alternatives. Impairment is further discussed on page 228.

- *Determine cumulative effects* — Cumulative effects were determined by evaluating the incremental effect of the alternative when combined with other past, present, or reasonably foreseeable future actions within and outside of the area of potential effect. (Also see the discussion on page 228).

TOOLS USED TO ANALYZE ENVIRONMENTAL CONSEQUENCES

In addition to the methodology discussed above, several other tools were used to help predict impacts to the physical and social environment. Some of these tools are presented below; others that were uses for specific impact topics are discussed in the following sections of this chapter.

Each alternative represents a set of management variables (group size, launches per day, etc.) that creates a corresponding set of indicators (trips at one time, user discretionary time, etc.). These are discussed in depth in Chapter 2. The analysis is based on how the variables and indicators that make up each alternative would interact with each other; the variables for each alternative are presented in the following tables. Table 4-1 summarizes key variables and indicators of use for each of the Lees Ferry to Diamond Creek alternatives. Table 4-2 ranks the alternatives by the estimated totals for user-days, passengers, and user discretionary time, based on the yearly totals presented in Table 4-1.

TABLE 4-1: SUMMARY OF ALTERNATIVES: LEES FERRY TO DIAMOND CREEK

	Alternatives							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Number of Motor / No-Motor Months	9/3	0/12	0/12	8/4	6/6	6/6	8/4	6/6
Months with No Motors	Sept 15–Dec 15	All	All	Mar, Apr, Sept, Oct	Oct–Mar	Jul–Dec	Sept–Dec	Sept–Feb
Maximum Number of Launches per Day								
Summer	9	4	4	5	6	6	6	6
Shoulder	7	2	3	3	3	4	5	3
Winter	1	1	2	1	2	2	2	1
Maximum Group Size (including guides)								
Commercial Motor	43	N/A	N/A	25	30	30	40	32/24
Commercial Oar	39	25	30	25	25	30	30	32/24
Noncommercial Standard	16	16	16	16	16	16	16	16
Noncommercial Small	N/A	8	N/A	8	8	8	8	8
Maximum Trip Length to Diamond Creek (in number of days)								
Summer (May–August)								
Commercial Motor	18	N/A	N/A	10	8	10	8	10
Commercial Oar	18	16	16	16	14	16	14	16
Noncommercial	18	16	16	16	16	16	14	16
Shoulder Seasons (March–April / September–October)								
Commercial Motor	18	N/A	N/A	10	8	10	8	10
Commercial Oar	21	18	18	18	16	18	16	18
Noncommercial	21	18	18	18	18	18	16	18
Winter (November–February)								
Commercial Motor	30	N/A	N/A	18	N/A	18	N/A	N/A
Commercial Oar	30	N/A	21	21	N/A	21	N/A	21
Noncommercial Motor	30	N/A	N/A	18	N/A	18	18	N/A
Noncommercial Oar	30	18	21	30	21	21	21	25

	Alternatives							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Whitmore Exchanges								
Helicopter Exchanges (months allowed)	All	None	None	None	Apr–Sept	Jan–Jun	Jan–Aug	May–Aug
Hiking Exchanges (months allowed)	All	None	All	All	All	All	All	Mar., Apr., Sept., Oct.
Maximum Number of Trips at One Time	70	60	60	58	60	54	53	60
Maximum Number of Passengers at One Time	1,095	877	900	890	972	972	8,985	982
Probable Total User-Days								
Commercial	113,083	97,694	166,814	137,368	115,500	128,689	115,500	115,500
Noncommercial	58,048	74,523	115,783	85,946	121,683	106,457	134,410	102,725
Total	**171,131**	**172,218**	**282,598**	**223,314**	**237,183**	**235,146**	**249,910**	**218,225**
Probable Total Yearly Passengers								
Commercial	18,891	7,914	17,686	14,979	16,120	18,671	19,688	19,835
Noncommercial	3,571	4,980	7,543	5,449	7,693	6,745	8,992	6,482
Total	**22,461**	**12,894**	**25,228**	**20,427**	**23,812**	**25,415**	**28,680**	**26,317**
Opportunity for Winter Commercial Trips?	Motor or oar	No	Oar	Motor or oar	No	Motor or oar	No	Oar
User Discretionary Time (total yearly hours)	355,081	576,754	752,496	710,079	569,603	518,889	421,073	554,103

TABLE 4-2: RANKINGS BY ALTERNATIVE AND SEASON BASED ON PROJECTED USER-DAYS, PASSENGERS, AND USER DISCRETIONARY TIME — LEES FERRY TO DIAMOND CREEK

Alternative	Winter	Rank	Shoulder Seasons	Rank	Summer	Rank
Total User-Days						
A	6,159	8	43,103	8	121,869	2
B	14,459	7	50,339	7	107,419	6
C	82,959	1	89,519	1	110,120	5
D	39,759	5	60,815	5	122,739	3
E	47,466	4	67,879	4	121,836	4
F	54,093	3	78,762	3	102,291	7
G	62,323	2	85,603	2	101,984	8
H	33,828	6	59,154	6	125,243	1
Total Passengers						
A	318	8	4,016	7	18,128	2
B	927	7	3,475	8	8,492	8
C	5,027	1	8,950	2	11,252	7
D	2,242	5	4,421	6	13,765	6
E	2,782	4	5,801	5	15,230	3
F	3,094	3	8,368	3	13,954	5
G	3,710	2	10,031	1	14,939	4
H	1,855	6	6,330	4	18,132	1
Total User Discretionary Time (in hours)						
A	6,855	8	53,721	8	294,506	6
B	20,229	7	125,081	4	431,444	2
C	228,981	1	188,426	1	335,089	5
D	114,409	2	134,029	3	461,641	1
E	80,727	5	115,114	5	373,761	4
F	113,619	3	135,764	2	269,507	7
G	102,907	4	88,208	6	229,958	8
H	64,518	6	87,548	7	402,037	3

Highest ranking = 1, lowest ranking = 8

Numbers based on projected yearly use (see Chapter 2)

TABLE 4-3: ALLOWABLE USE TYPES AND LEVELS — DIAMOND CREEK TO LAKE MEAD ALTERNATIVES

	Alternatives				
	1	2	3	4	5
Diamond Creek Launches (maximum group size, including guides)					
Noncommercial	Maximum of two launches per day (16 people each)	Same as alternative 1.	Same as alternative 1.	Same as alternative 1.	Same as alternative 1.
HRR Day Trips	Average of one launch per day (up to 100 people)	Peak season: two launches per day (30 people). Non-peak season: one launch per day (30 people)	Peak season: three launches per day (30 people). Non-peak season: two launches per day (30 people)	Peak season: variable (40 people). Non-peak season: two launches per day (35 people)	Same as alternative 4.
HRR Overnight Trips	Average of one trip per week (34 people)	One trip per day (30 people)	Two trips per day (30 people)	Peak season: three trips per day (20 people). Non-peak season: one trip per day (20 people)	Same as alternative 4.
Campsites					
Available Campsites	15	15+1	15+2	15+3	15+3
Modification of New Campsites*	N/A	Low	Medium	Low	Low
Quartermaster Area Dock					
Type of Dock	Two small floating docks (deteriorated).	None.	One small floating dock at RM 262.5. No other docking facilities	Same as alternative 3.	One large floating dock at RM 262.5.
Pontoon Operations					
Maximum Daily Passengers**	Peak season: 188 Non-peak season: 160	0	400	150	960
Upriver Travel from Lake Mead					
Allowable Destination	Unlimited below Separation Canyon.	Below RM 262.	Below Separation Canyon.	Below RM 260, unless Lake Mead at full pool, then tow-outs below Separation Canyon.	Below RM 273.
Allowable Use	Unrestricted commercial pick-ups, tow-outs, and non-commercial jetboats.	Commercial pick-ups: peak season — two per day; non-peak season — none. Tow-outs allowed below RM 262.	Four commercial pick-ups per day, year-round.*** Two jetboat tours per day in the peak season. Tow-outs allowed below Separation Canyon.	Commercial pick-ups: peak season — four per day; non-peak season — one per day. Tow-outs below RM 260.	No jetboats allowed. Tow-outs.

* Low — vegetation removal only; medium — vegetation removal and limited supply storage.

** Passenger access and egress occurs via helicopter.

*** Commercial pickups would be allowed to shuttle kayak trips up to RM 273.

To analyze the effect of each alternative, resource maps of known natural and cultural resources and visitor stopping points (camp, lunch, and attraction sites), including data on use intensity and known levels of impacts, were created to assist in identifying areas where sensitive resources overlapped with visitor use areas. The maps were used in conjunction with data from the Grand

Canyon River trip simulator, as well as data from the Biophysical Impact Monitoring Program (see Chapter 2) to predict changes in use patterns in resource-rich areas. Consequently, analysts determined to what extent each alternative would have a direct effect on the vulnerability of certain sensitive areas.

INCOMPLETE OR UNAVAILABLE INFORMATION

The DO #12 Handbook offers guidance on how to address data gaps in an environmental impact statement (NPS 2001b). If "such information cannot be obtained due to excessive cost or technical impossibility, the proposed alternative for decision will be modified to eliminate the action causing the unknown or uncertain impact or other alternatives will be selected" (sec. 4). In the case where alternatives cannot be modified to eliminate unknown or uncertain potential impacts, the handbook states in section 4.5 that the National Park Service is required to address the following (in accordance with 42 CFR 1502.22):

- the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment
- a summary of existing credible scientific adverse impacts which is relevant to evaluating the reasonably foreseeable significant adverse impacts
- an evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community

Data that are incomplete or unavailable are addressed per impact topic in the following sections of this chapter.

ASSUMPTIONS

Several assumptions were made in evaluating the effects of recreational use alternatives for the Colorado River corridor at Grand Canyon National Park. These assumptions were applied to all of the impact topics unless otherwise noted.

- *Analysis Period* — The analysis period addresses potential short- and long-term effects from the selected alternative for the *Colorado River Management Plan,* which has a 10-year planning horizon.
- *Analysis Area* — The analysis area includes the Colorado River corridor from Lees Ferry through Grand Canyon National Park and adjacent tribal lands to Lake Mead. The analysis area includes areas commonly visited by river runners hiking off the river. Except for cumulative impacts analyses or as specifically stated in the text, the analysis area does not include areas upstream from Lees Ferry (including Glen Canyon Dam), Lees Ferry itself (which is part of Glen Canyon National Recreation Area), or areas in Lake Mead National Recreation Area (including Pearce Ferry and South Cove).
- *Beaches* — The diminished sediment load in the river below Glen Canyon Dam has resulted in, and will continue to result in, an overall reduction in the total number of beaches and individual beach sizes (see the discussion of soils in Chapter 3).

- *Flows* — The analysis assumes flows will be consistent with the annual operations plan for Glen Canyon Dam, prepared by the Bureau of Reclamation annually. The flow regime is consistent with the record of decision on Glen Canyon Dam operations, and it assumes minimum releases to meet the requirements of the 1922 Colorado River Compact. Flows will remain in the range of 5,000–25,000 cfs, with the possibility of short-term experimental releases of up to 45,000 cfs.
- *Group Size* — Larger groups use more space. While large campsites can accommodate larger numbers, those campsites are diminishing both in size and number, and they are not distributed evenly throughout the canyon. Thus, larger groups are known to spread up into the old high-water zone, causing impacts to natural and cultural resources that otherwise would be relatively undisturbed. Additionally, larger groups are more likely to exceed the carrying capacity of attraction sites. This affects not only the physical resource, but also the social environment, since crowding is known to adversely impact visitor experience.
- *Variety of Opportunities* — An important aspect of analyzing impacts is the determination of the range of opportunities for various trip types. The analysis of public scoping comments clearly indicated that there is no one definition of the ideal Grand Canyon river trip. For example, while some people may prefer a trip without motors of any kind, some may prefer a motorized trip that ends with a helicopter ride. Still others may prefer motorized trips, but find the prospect of encountering a helicopter shuttle unacceptable. Some visitors want a social experience while others prefer to vacation with a small group that is unlikely to encounter other groups. Some want short trips, others want long trips. Preferences also vary on desired seasons and whether trips are commercial or self-guided. All of these variables, and the degree to which each is offered, are considered in any analysis that incorporates the range of trip types or variety of trip opportunities.
- *Commercial Operations* — Commercial companies currently seek to optimize use of their allocations (see "Socioeconomic Conditions" in Chapter 3). Averages for trip types and seasons assume that group size and trip length tendencies from the past will continue for trips that meet the specific alternative's limits, and other trips would adjust to the new limit thresholds.
- *Demand* — Overall, demand for recreational trips (both commercial and noncommercial) will continue to exceed supply.
- *Winter Use* — Analysis assumed a solid demand for winter use, based on winter test results (see Chapter 1).
- *User Discretionary Time* — User discretionary time is a calculation of the cumulative amount of time people have to experience and explore the river corridor during their river trip. The type of trip, the length, and the time of year (seasonal availability of daylight) all affect the amount of time that visitors have to experience the Grand Canyon and interact with the environment. While this interaction carries a potential for resource impacts, that potential is weighed against other factors such as group size and the number of trips at one time. Further, user discretionary time is also an indicator of whether visitors are allowed enough time to experience the resources and values of the Grand Canyon.

- *Interconnectivity of Variables* — Analysis focused on the interaction of the variables and indicators associated with each alternative (see Chapter 2). For example, the maximum number of daily launches and allowable trip lengths can work to mitigate or exacerbate impacts caused by larger groups. Therefore, the analysis focused on considering the interaction of the suite of variables and indicators that made up each alternative.
- *Grand Canyon West Operations* — Grand Canyon West is a 9,000-acre, tour-related facility operating on the Hualapai Reservation under the Grand Canyon Resort Corporation, which is wholly owned by the Hualapai Tribe. Development plans for Grand Canyon West include airport expansion, road and viewpoint access improvements, construction of cluster lodging, employee housing, camping and RV sites, a rim to river tram, a golf course, and a health and wellness center. Current operations of Grand Canyon Resort Corporation include Hualapai River Runner (HRR) trips, pontoon tours (with helicopter access and egress), helicopter rim-to-river tours, van tours to Diamond Creek and Grand Canyon West, hotel and ranch accommodations, and excursions to resort facilities and overlooks. Of these operations, only the HRR and pontoon trips, which access the Colorado River as it passes through Grand Canyon National Park, are included within the scope of the Colorado River Management Plan. All other Grand Canyon Resort Corporation operations are conducted on sovereign Hualapai Tribal lands and are not under the purview of this plan. However, all aircraft operations are under the authority of the Federal Aviation Administration and are subject to their rules and regulations.
- *Helicopter Use in the Quartermaster Area* — The National Park Service has no authority over helicopter flights on Hualapai lands. It is assumed that look-and-leave flights into the canyon from Grand Canyon West and Las Vegas and land above the high-water mark will continue to operate regardless of which set of alternatives is selected. As such, the analyses for natural soundscape and visitor experience in the Quartermaster area consider impacts from this use.
- *Helicopter Use Associated with Pontoon Operations* — Currently, all pontoon trip passengers access and egress the docking facilities via helicopter flights that land at pads at RM 262 and RM 263. It is assumed that pontoon trip passengers will continue to use helicopters for access and egress. It is also assumed that these pads may also be used for other types of helicopter tours. The National Park Service has no authority over helicopter flights that land and take off on Hualapai tribal lands.

Resource-specific assumptions are discussed per impact topic in the following sections of this chapter.

IMPACT ANALYSIS

The impact analysis uses the tools and methodology discussed above to determine how each alternative would impact the environment and meets the management objectives for each impact topic.

CUMULATIVE IMPACTS

Federal agencies must assess cumulative effects in an environmental impact statement. According to the CEQ regulations (40 CFR 1508.7), cumulative effects are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such actions." Cumulative effects are considered for each of the alternatives and are addressed per impact topic. Major past, present, and reasonably foreseeable future actions considered in this analysis include the following:

- Operation of Glen Canyon Dam, including proposed experimental dam releases, fluctuating flows, temperature stabilization efforts, and removal of nonnative fish.
- Cooperative agreement between the Hualapai Tribe and Grand Canyon National Park, and cooperative management among the Hualapai Tribe, Grand Canyon National Park, and Lake Mead National Recreation Area of the area from National Canyon to Lake Mead.
- Tamarisk management and tributary restoration at Grand Canyon National Park.
- Lake Mead National Recreation Area's *Lake Management Plan.*
    - Closure of Pearce Ferry due to drought and declining water levels.
    - Increased use of the South Cove takeout.
- Backcountry and wilderness management at Grand Canyon National Park.
- Fire management at Grand Canyon National Park.
- Hualapai Tribe actions solely on their lands.
- Diamond Creek activities
- Grand Canyon Parashant National Monument planning.
- Air tour management efforts at Grand Canyon National Park.
- Comprehensive noise management plan at Grand Canyon National Park.

CONCLUSIONS, MITIGATIONS, AND IMPAIRMENT ASSESSMENT

The conclusion for each impact topic summarizes all major findings in the impacts analysis for each alternative. As part of this summary, reasonable mitigations are identified when applicable for reducing or eliminating impacts, and their effect on the impact assessment is discussed.

Finally, the conclusion includes a determination of whether the alternative is likely to cause impairment of park resources and values. NPS *Management Policies, 2001* (2000) require the analysis of potential effects to determine whether or not actions would impair park resources. The fundamental purpose of the national park system, as established by the Organic Act and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. NPS managers must always seek ways to avoid, or to minimize to the greatest degree practicable, adversely impacting park resources and values. However, the laws do give the National Park Service the management discretion to allow impacts to park resources

and values when necessary and appropriate to fulfill the purposes of a park, as long as the impact does not constitute impairment of the affected resources and values. Although Congress has given the National Park Service the management discretion to allow certain impacts within parks, that discretion is limited by the statutory requirement that the National Park Service must leave park resources and values unimpaired, unless a particular law directly and specifically provides otherwise. The prohibited impairment is an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of these resources or values. Whether an impact meets this definition depends on the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question, along with other impacts that are in existence. An impact to any park resource or value may constitute impairment, but an impact would be more likely to constitute an impairment to the extent that it has a major or severe adverse effect on a resource or value whose conservation is:

- necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; or
- identified as a specific goal in the park's general management plan or other relevant NPS planning documents.

Impairment may result from NPS activities in managing the park, visitor activities, or activities undertaken by concessioners, contractors, and others operating in the park. A determination on impairment is made for each impact topic.

IMPACTS ON NATURAL RESOURCES

SOILS

ISSUES

External and internal scoping sessions identified several river recreation related soil resource issues, as summarized below:

- Protection of ecological and cultural resources should be the National Park Service's first management priority
- Resources should be monitored for impacts
- Social trailing is a problem and should be reduced; the National Park Service should mark and maintain trails
- The National Park Service should modify terrain only where habitat preservation is necessary.
- Visitor impacts on beaches are a problem.
- Beaches show little evidence of visitor impact.
- Restore beaches by sediment infusion, stabilization, reduction of encroaching vegetation.
- Consider closing areas experiencing excessive impacts.
- Tributaries are an exceptional resource that should be managed and protected from visitor impacts.
- Many sites are at or near thresholds for acceptable condition. They need frequent mitigation.
- River recreational activities contribute to beach erosion.
- Impacts of large groups are a problem when group size exceeds the amount of suitable camping area on diminishing beaches.
- NPS funding is inadequate to accomplish the amount of mitigation necessary at current use levels.

Shoreline and the New High-Water Zone

Direct effects on sand, silt, and loam substrates are evident in areas regularly used for river recreation along the three hydrologic zones (the shoreline, the new high-water zone, and the old high-water zone) found along the mainstem of the Colorado River. Howard and Dolan (1976) and Phillips et al. (1986) reported erosion of beach and pre-dam terrace deposits in the new and old high-water zones that were caused by river runners camping overnight, stopping for lunch, and/or visiting attraction sites. Heavy foot traffic along shorelines, particularly between moored boats and the high-use areas of sites, creates access trails and dislodges sand downslope. This effect is most pronounced on steep slopes in the new high-water zone that are composed of

coarse sand and devoid of vegetation that anchors sand and soil. These young alluvial substrates erode easily and regenerate very slowly. Drier, looser substrates move downhill in greater volume than moist, wet packed sand, so beaches are highly susceptible to erosion during hot dry months when evaporation rates are high (Valentine and Dolan 1979). Foot traffic also dislodges soil along tributary streams and at seeps and springs, increasing alluvial erosion in valuable riparian habitats. With repeated use, access trails created by river runners can become entrenched, funneling additional sand down to the river, especially during summer rainstorms or spring runoff. Foot traffic also roughens the surface of sand and silt, increasing the effects of wind and water erosion.

Erosion impacts to shorelines are also caused by moored boats jostling against sand banks (Howard and Dolan 1976) and turbulence and wakes created by motorboats and jetboats (Kakoyannis and Stankey 2002). Below Separation Canyon in the Lower Gorge, substantial wakes are thrown by 40-foot-long jetboats equipped with engines generating 400 to 1,050 horsepower (hp) per boat, traveling up to 40 mph (Mengel, pers. comm. 2003b). Soil erosion indirectly affects water quality by making water more turbid. Erosion from recreational activities also contributes to beach sediment loss caused by Glen Canyon Dam operations. Additional impacts in the new high-water zone include trampling of vegetation or intentional removal of plants, which destabilizes the soil, increasing the potential for soil erosion.

PHOTO 4-1: BANK EROSION AND MOTORBOAT WAKES IN THE LOWER GORGE

Old High-Water Zone and Uplands

In the old high-water zone and upland talus slopes, poorly developed, fine-grained eolian sediments are easily impacted by river recreationists. Soils on flat upland terraces and cliffs are slightly more stable due to the presence of older, more mature native vegetation. These sediments can become less resistant if river runners cut multiple trails through the vegetation, damage well-established desert scrub, and erode the terrace banks. Multiple trails in the old high-water zone are often created when group members leave the main established trail and blaze new trails while hiking to attractions. Multiple trails are more likely to form on the flat terraces (see Photo 4-2), since it is easier for users to spread out in open areas (Hendee, Stankey, and Lucas 1990).

Many groups of visitors walking repeatedly over the same trails day after day compact the trail substrates, packing soil particles closer together and causing a reduction in the volume of air. Ideal soil conditions for the development of vegetation allow for about 50% of the total soil volume to be pore space filled with equal volumes of air and water. When these soil conditions are altered, vegetation growth becomes limited (McBride, Martin, and Kennedy 1988) and soil microbiota lack sufficient oxygen and find it difficult to penetrate dense soil (Reeves et al. 1979). During dry periods, dense soils increase runoff and absorb less water (Settergen and Cole 1970). During the summer monsoon season and spring runoff, wet soils in the old high-water zone become more susceptible to compaction by foot traffic, and trails can become gullies as draining water follows the path of least resistance.

PHOTO 4-2: MULTIPLE TRAILING AT NANKOWEAP

Fragile biological (cryptogamic) soil crusts composed of fungi, cyanobacteria and lichens cover much of the old high-water zone, upland, and side canyon soils. These colonizing organisms contribute organic matter that aids water retention and paves the way for the growth of higher plants. The Cyanobacteria component of the soil fixes atmospheric nitrogen into amino acids and enriches the soil for plant growth. When river recreationists walk off established trails, they inadvertently trample the stabilizing soil crusts (see Photo 4-3). Once these crusts are crushed by footprints, crust functions are reduced, and trampling effects remain obvious for a many years due to slow crust regeneration (Cole 1990). Soils subject to the direct effects of human disturbance can also provide a competitive edge to invasive exotic plant species and are more susceptible to dust generation. Helicopter use at Whitmore and Quartermaster further increase dust generation.

PHOTO 4-3: EXAMPLE OF BIOLOGICAL SOIL CRUST DAMAGE

Larger groups are also more likely to disturb larger areas (Hendee, Stankey, and Lucas 1990). When large groups use medium or small sized camping beaches, visitors searching for privacy establish new tent sites in the old high-water zone. This expands the camping area, denudes stabilizing native vegetation, creates multiple barren cores, damages biological soil crusts, exposes mineral soil, and compacts old high-water zone soils. The Colorado River human impact monitoring program (Brown and Jalbert 2003) has documented significant changes to soil and vegetation resources caused by recreationists, as well as a strong relationship between beach size and vegetation and soil impacts. As beach size is diminished, impacts to soil and vegetation increase in the old high-water zone (Brown, pers. comm. 2004). Recreationists on longer trips have more time to explore the old high-water zone and hike to nearby attractions, increasing the area of possible impact and the probability of impacts occurring. Washburne and Cole (1983) observed that parties that stay longer at sites are more likely to develop or improve them.

GUIDING REGULATIONS AND POLICIES

Overarching laws, including the NPS Organic Act of 1916, the National Environmental Policy Act of 1969, and the National Parks Omnibus Management Act of 1998 are described in the "Introduction" to Chapter 4.

The National Park System Resource Protection Act (16 U.S.C. 590a and 590b) states that soils erosion on federal lands is a menace to the national welfare and that it shall be national policy to permanently control and prevent soil erosion and thereby to preserve natural resources.

Pursuant to 36 CFR 2.1(b), the park superintendent may restrict hiking or pedestrian use to a designated trail or walkway system. Leaving a trail or walkway to shortcut between portions of the same trail or walkway, or to shortcut to an adjacent trail or walkway in violation of designated restrictions is prohibited.

The NPS *Management Policies 2001* state that the Park Service "will actively seek to understand and preserve soil resources of parks, and to prevent to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources" (NPS 2000d, sec. 4.8.2.4.). Management action will be taken by superintendents to prevent or minimize adverse, potentially irreversible, impacts to soils. Soil conservation and soil amendment practices may be implemented to reduce impacts.

The Grand Canyon National Park 2004 Commercial Operating Requirements state the following with regard to multiple trails and campsite impacts:

> *Section IV.G. Multiple Trails:* Multiple trailing, with its consequent impacts on vegetation and soils, comprises a perennial problem at attraction sites and along backcountry trails. Guides should stress to their passengers the need to stay on established trails. A guide or trip leader familiar with the trail to be taken will lead all group hikes.
>
> *Section IV.H. Campsite Impacts:* Impacts above the sandy, post-dam riparian zone at camping areas continue to be a problem. Desert and old pre-dam riparian plant communities are particularly susceptible to damage and erosion due to trampling. Guides should stress the necessity of conducting camp activities in the more resistant post-dam sandbar areas. Passengers should be instructed not to blaze new hiking routes or sleeping areas in the fragile desert zones.

MANAGEMENT OBJECTIVES FOR SOILS

As stated in Chapter 1, the *Colorado River Management Plan* management objective for soil resources is to preserve and protect natural soil conditions by minimizing impacts to soils from river recreational activities. How well each alternative would meet this management objective is included in Table 2-4 and Table 2-7 in Chapter 2.

METHODOLOGY FOR ANALYZING SOIL IMPACTS

The general methodology for analyzing impacts to resources is discussed in the "Introduction" to Chapter 4. The impact analysis was based on the interaction of context, duration, timing, and intensity of visitor impacts. Intensity of impacts was defined using resource specific impact thresholds.

Tools Used to Analyze Effects to Soils

In addition to the river trip simulator, the user discretionary time model, and the Colorado River Management Plan Mixed Resource Map, data from the 2003 NCRS Grand Canyon Soil Survey and the Colorado River Impact Monitoring Program (Brown and Jalbert 2003) were used. NPS staff compiled all available information on soil resources and soil impacts in the area of effect. NPS files, GCMRC research, and Hualapai Tribe resource files were used, as well as personal communications with resource specialists.

Impact Thresholds

Impacts specific to soils are characterized for each alternative based on the impact thresholds presented below. Context, duration, and timing are also defined. The methodology for how the determination of impact intensity, context, duration, and timing for a specific impact topic then relates to the cumulative impact analysis and the determination of impairment is presented in Figure 4-1 in the "Introduction."

Intensity

Negligible — Adverse impacts to soils, including biological crusts, would not be perceptible or measurable. Beneficial impacts would improve the condition of soils at minute levels. Any changes to soil productivity, integrity, stability, or fertility would be imperceptible.

Minor — Beneficial or adverse effects to soils and biological crusts would be barely perceptible or measurable. Any adverse impacts to soil productivity, integrity, stability, or fertility would be small and reversible. Beneficial effects would improve the condition of soils slightly. If mitigation was needed to offset adverse effects, it would be relatively simple to implement and would likely be successful. A beneficial effect would slightly reduce the level of mitigation needed.

Moderate — Beneficial or adverse impacts to soils and biological crusts would be readily perceptible and measurable. Effects to soil productivity, integrity, stability, or fertility would be readily apparent, and they would result in a change to the soil character. Mitigation measures would be necessary to offset adverse effects and would likely be successful. Beneficial effects would substantially improve the condition of soils, greatly reducing the amount of necessary mitigation.

Major — Adverse impacts to soils and biological crusts would be readily perceptible, measurable, and constitute a substantial change from natural conditions. Effects to soil productivity, integrity, stability, or fertility would be readily apparent and would substantially change the character of the soils. Mitigation measures to offset adverse effects would be needed, they would be extensive, and their success would not be guaranteed. Beneficial effects would return soils back to natural conditions, and mitigation would not be necessary.

Context

Localized — Impacts occur at campsites, lunch stops, attraction sites, and along trails within a hydrologic zone (shoreline, new high-water zone, old high-water zone), and up side canyons or at seeps and springs.

Regional — Impacts occur within an entire recreational opportunity spectrum Zone 1, 2, or 3.

Duration

Short term — Short-term impacts occur over one season, and soils return to pre-disturbance condition the next year.

Long term — Long-term impacts occur over several seasons, lasting longer than one year.

Timing

Soils are susceptible to erosion, compaction and gullying during spring runoff and summer monsoons. Sand erosion in the new high-water zone is worse during the dry, hot months of the year.

Biological soil crusts are susceptible year-round, but crusts are particularly vulnerable during the dry, hot months.

Mitigation of Effects

Previous mitigation efforts indicate that specific measures can be effective in reducing impacts to soils if adequate funding, staffing, monitoring, and implementation of the measures are maintained. Additional mitigation measures not already incorporated into the alternatives that are judged likely to reduce impacts to soils include the following:

- Increase educational efforts and teach users how to avoid impacting soils.
- Provide river runners a map of small, medium, and large campsites and require parties of 12 or fewer people to use small campsites, 13–24 to use medium campsites, and 25 or larger to use large campsites.
- Identify protocols for hardening, closing and resting, or rehabilitating campsites or attraction sites and link them to systematic monitoring programs.
- Delineate campsites, harden sites, and clear nonnative vegetation when feasible so there are sufficient tent sites in the new high-water zone.
- Maintain single main trails, and move or obliterate trails in undesirable areas (e.g., social trailing, or trails over cultural sites). Build and/or maintain erosion control structures as needed to protect sensitive resources and stabilize soils. Recontour ground surfaces to promote drainage to appropriate areas.
- Revegetate impacted areas, restore native plant associations, and remove noxious weeds.
- Work with the Adaptive Management Work Group to attempt to reduce beach erosion and restore beach sediments.
- Create new limits of acceptable change (standards that indicate the level of change at which action is to be taken) for the soil resource in order to trigger mitigation actions before impacts become major and irreversible.
- Fully fund a mitigation program to keep impacts at minor to negligible intensity levels.

Cumulative Impacts

Cumulative impacts on soils were determined by combining the impacts of each alternative with other past, present, and reasonably foreseeable future actions, as listed in the "Introduction" to Chapter 4 (see page 228).

Impacts to soils from river recreational activities would compound existing impacts from Glen Canyon Dam operations, the existence of Hoover Dam, backcountry hiker and angler use, administrative use, past feral burro use, and naturally occurring storms and flash floods that wash

down tributary canyons. As previously discussed, Glen Canyon Dam impedes natural sediments from moving downstream to replace eroding beaches through Grand Canyon National Park. Fluctuating flows and experimental floods heavily affect removal and deposition of beach sediments in Marble Canyon. In the Lower Gorge, Hoover Dam impedes the flow of sediment downstream, and large amounts of sand and silt are deposited in the west end of the canyon. The presence of these dams have adverse, regional to localized, year-round, long-term, moderate to major effects on soils. Backcountry hikers and anglers access campsites at several sites along the river and contribute to soil erosion, trailing, and compaction. Administrative trips, although mostly limited to group sizes of 16 or less, contribute to soil impacts in the corridor and up side canyons. This use has localized, adverse, year-round, short- to long-term, minor to major effects on soils. In the late 1970s feral burros were impacting old high-water zone soils in areas such as around Rampart Cave, Shinumo, and RM 209 (NPS 1979b); impacts continued into the 1980s. Researchers from the Museum of Northern Arizona studying the effects of feral burros on soils in 1977 concluded that feral burros change the natural conditions of park soils through soil compaction, soil erosion, and trampling of *Tortula* sp. moss crusts. Park staff revisited these plots in 2003 and noted that the multiple trails created by the feral burros were still apparent after 20 years (Leslie 2004b). Past feral burro impacts on soils have been localized, adverse, year-round, long term, and moderate to major.

Assumptions

General assumptions used for analysis of effects are discussed in the "Introduction" to this chapter. Assumptions that specifically relate to the management alternatives and their effect on soils are presented below:

- The geographic area evaluated for soil impacts includes the river corridor from Lees Ferry to Lake Mead, areas accessible to river users for a distance of 2 miles from the river corridor, and the three riparian soil zones (shoreline, new high-water zone, and old high-water zone, including uplands) at campsites, lunch stops, attraction sites, and along tributaries.
- Impacts to biological soil crusts are long term because when they are trampled, it takes many years for them to recover.
- Noncommercial and commercial groups are considered to behave similarly at campsites; however impacts to soils from small groups compared to large groups are different. Large groups tend to spread out more and affect old high-water zone soils, especially on smaller sized beaches.
- The longer that groups are at a site, the greater the probability for impacts to soil resources to occur in the old high-water zone and up side canyons.
- The shorter the trip length, the fewer opportunities parties have to layover at sites.
- Only a small portion of all of the soils in Zone 1 are affected by river-running activities, so regional impacts to soils are negligible for all Lees Ferry alternatives.
- Increased user discretionary time is a better indicator of probable impacts to the old high-water zone and side canyons than impacts to the shoreline and new high-water zone, because even if parties have minimal discretionary time, they still need to camp each

night and will be using the shoreline and new high-water zone on a daily basis. Increasing user time allows parties time to hike into the old high-water zone and side canyons.

- Longer trips have, by their nature, increased amounts of time for visitors to interact with the canyon environment. This increased time has the potential to allow greater interaction with soil resources. This is particularly true for side canyons, as longer trips are designed to allow visitors opportunities for exploration. Off-season hiking (shoulder and winter months) is more conducive to exploring side canyons, as the extreme heat of the summer precludes hiking too far from the river itself.

IMPACT ANALYSIS — LEES FERRY ALTERNATIVES

The differences between alternatives are described in the following sections. The Lees Ferry alternatives are not compared to the Lower Gorge alternatives due to the differences in management, density of users, and the length of the river (226 miles from Lees Ferry to Diamond Creek and 50 miles from Diamond Creek to Lake Mead).

Alternative A (Existing Conditions)

Under Alternative A management of recreational use would continue to allow large group sizes, with a maximum commercial group size of 43, long trips with a maximum winter trip length of 30 days, and spikes in trips at one time, people at one time, and daily launches (see Table 4-1). User-days would remain capped at current levels, which would result in approximately 22,500 passengers per year. Highest use occurs in the summer months and lowest use in the winter months. User discretionary time would remain relatively similar to current levels (the lowest of all the alternatives). Whitmore exchanges would occur year-round, and there would be a three-month no-motor season in the fall. Commercial motor and oar trips would be allowed in the winter.

Analysis. The limits of acceptable change in the 1989 *Colorado River Management Plan* state that there will be no more than one primary trail from a mooring location to a destination site, through the old high-water and desert (uplands) zones per site. The National Park Service has attempted to block and revegetate unwanted trails; however, due to a lack of funding and resources, these efforts have been minimally successful. Results from the Colorado River human impact monitoring program (Brown and Jalbert 2003) show that 96% of the 25 campsites inventoried during July and October 2003 have more than 10 social trails per campsite (see Table 4-4), which far exceeds the 1989 limits of acceptable change.

TABLE 4-4: NUMBER OF SOCIAL TRAILS

	Trails per Site					
	0–10	11–20	21–30	31–40	41–50	51+
Number of Sites	1	3	7	4	3	7
Percentage of Sites	4%	12%	28%	16%	12%	28%

SOURCE: Preliminary data from biophysical impact survey conducted in 2003 by Mathieu Brown, Northern Arizona University. Provided by Grand Canyon National Park Science Center.

The Colorado River "Commercial Operating Requirement" prohibit camping activities in the old high-water zone (NPS 2003g), yet 63% of the 25 camp pads surveyed in 2003 Colorado River human impact monitoring program (Brown and Jalbert 2003) have pads in the old high-water zone, with a maximum of 16 campsites. More than half of these sites show soil and vegetation resource impacts related to camping activities. About 78% of the campsites inventoried by Brown and Jalbert in 2002 showed evidence of biological soil crust trampling.

Current park management efforts to mitigate soil erosion and compaction due to recreational use impacts include campsite delineation, trail maintenance and obliteration of social trails, erosion control, site stabilization, beach hardening, and revegetation. Park vegetation and trails staff routinely examine the condition of 148 campsites and attraction sites to determine mitigation actions needed to restore soil resources. Of these localities, approximately 60% require routine (semiannual, annual, or biannual) maintenance to remedy visitor impacts to soils. Table 4-5 indicates the proportion of these sites that require erosion control/site stabilization, social trail obliteration, trail maintenance, and/or revegetation on a routine basis.

TABLE 4-5: CAMPSITES AND ATTRACTIONS REQUIRING ROUTINE MAINTENANCE TO REMEDY VISITOR-RELATED SOIL IMPACTS

	Erosion Control/ Site Stabilization	Social Trail Obliteration	Trail Maintenance	Native Plant Revegetation
Number of Sites	75	88	77	68
Percentage	50.7%	59.5%	52.0%	46.0%

SOURCE: Unpublished data on file at Grand Canyon National Park Science Center.

NOTE: 148 total campsites monitored.

Under Alternative A erratic launch patterns (with a maximum of nine launches per day in summer) create crowding at attraction sites. This alternative would continue to allow for large group sizes, increasing the probability that soil impacts (erosion and multiple trailing) would occur. When several large groups visit attraction sites at the same time, the probability of soil impacts magnifies. Only 25% of the campsites along the river can accommodate groups of 36 people or more. Large groups using the more abundant medium-sized beaches (with capacities of 24 or less) tend to spread out into the old high-water zone, adversely affecting biological soil crusts, damaging stabilizing vegetation, and creating barren areas for tent sites. This alternative has the highest number of trips at one time and people at one time, so soils at campsites and attraction sites would continue to be impacted repeatedly on a daily basis. This repetitive activity increases soil compaction. Together these factors have localized, adverse, short- to long-term, seasonal to year-round, moderate to major effects on soils.

Soils in the new high-water zone are susceptible to erosion during hot, dry months. Soils in the old high-water zone are vulnerable to foot traffic and gullying during spring runoff and late summer monsoons, as well as to trampling of sprouting, stabilizing vegetation in the spring. This alternative has the lowest user discretionary time and total annual user-days in winter and shoulder seasons, which has a minor, beneficial effect on soils; however, the total number of summer user-days is the second highest of all the alternatives, increasing potential impacts to soils during critical summer months. The high-use in the late spring and summer has localized, adverse, seasonal, short- to long-term, minor to moderate effects on soils.

The current mix of trip types creates an overall summer discretionary time the is lower than other alternatives, but longer allowable trip lengths allow users to layover at sites and to hike into side canyons, affecting upland and tributary soils. This alternative would continue to allow for the longest trip lengths of all the alternatives in the winter months when soil resources are less susceptible to erosion, but users who are allowed to spend multiple days at sites are more likely to contribute to multiple trailing and soil compaction impacts in the old high-water zone, uplands, and up side canyons. This has localized, adverse, year-round, short- to long-term, minor to moderate effects on soils.

Biological soil crusts are susceptible to trampling throughout the year, and groups with more time to hike into the old high-water zone and up side canyons are more likely to impact soil crusts. Larger groups that tend to spread out more have a greater potential to inadvertently trample biological soil crusts. This has localized, adverse, long-term, year-round, major impacts to soil crusts. Soil impacts at Whitmore are localized, but dust generation from helicopters can occur year-round.

Mitigation of Effects. Actions to mitigate effects would include all of the actions listed in the "Methodology for Analyzing Soil Impacts: Mitigation of Effects" section above. To attempt to reduce impacts to minor to negligible levels, an increase in the number of NPS staff to educate users about soil impacts, NPS patrols at campsites to ensure that river runners did not camp in the old high-water zone, and several more full-time staff to revegetate barren areas and block undesirable multiple trails would be required. This level of mitigation would only be reasonable and attainable in the new high-water zone with an increase in funding and staff. Impacts in the old high-water zone could not be reduced to minor under this alternative, even if increased levels of the proposed mitigations were employed.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short to long term, seasonal to year-round, and minor to major. Cumulatively, the effects of alternative A, when combined with these other past, present, and reasonably foreseeable actions, are regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative A makes a localized, adverse, short- to long-term, seasonal to year-round, minor to moderate contribution to these cumulative effects.

Conclusion. Under Alternative A adverse impacts to soils at sites along the mainstem shoreline would continue to be perceptible and measurable, requiring mitigation, with greater impacts in both the new and old high-water zones during the summer months due to soil vulnerability and the highest use. Soil impacts would occur primarily during summer, since winter and shoulder season use drops significantly. Motor use would continue to be allowed nine months a year, and some shoreline erosion can be contributed to motorboat wakes. However, within this dynamic hydrologic zone, sediment is constantly being removed and deposited due to other influences such as flash floods and debris flows, as well as Glen Canyon Dam operations, so impacts at many sites are more likely to be short term. At sites that never experience beach sediment replenishment, erosion impacts would be long term. Shoreline soil impacts would be adverse, localized, short-term to long-term, seasonal, and minor to moderate.

In the new high-water zone and along tributaries, soil impacts would continue to be readily perceptible and measurable at the majority of campsites and attraction sites. Compaction impacts along trails have changed the soil character. Soil impacts in this zone occur year-round; however, mitigation measures when fully employed can reverse many of the trailing, gullying, vegetation damage, and soil compaction impacts. New high-water zone soil impacts under Alternative A would be adverse, localized, short to long term, year-round, and moderate.

In the old high-water zone, including uplands and side canyons, soil impacts would often continue to be long term, especially to biological soil crusts. Impacts would occur year-round, but would be localized, tending to occur at campsites, attraction sites, and on trails leading up side canyons. Trailing, barren core, mineral soil exposure and compaction impacts, as well as biological soil crust impacts, have also changed the character of the soil. Many of these long-lasting impacts would take extensive mitigation to reverse. Therefore, soil impacts in the old high-water zone would be adverse, localized, long-term, year-round, and moderate to major.

Alternative A would have adverse, localized, short- to long-term, seasonal to year-round, minor to major effects on soils compared to natural conditions. There would be negligible additional effects from the continuation of current conditions. Alternative A would not result in the impairment of soil resources in Grand Canyon National Park. Cumulatively, impacts to soils are adverse, localized to regional, short to long term, and minor to major compared to natural conditions. Alternative A makes a localized, adverse, short- to long-term, seasonal to year-round, minor to moderate contribution to these cumulative effects.

Alternative B

Under Alternative B recreational motor trips would be prohibited and group sizes, the number of trips and people at one time, daily launches, user-days, and probable total yearly passengers would be at their lowest levels (see Table 4-1). Maximum trip length would be substantially reduced from 21 days in the shoulder seasons and 30 days in the winter to 18 days in these seasons and 16 days in the summer, and maximum commercial group size would be reduced from 43 to 25 people. An eight person noncommercial trip would be added. Total user discretionary time would increase in all seasons due to the lack of shorter motor trips. There would be no Whitmore helicopter exchanges. Total user-days would be about the same as now; however, the total number of passengers per year would decrease by around 10,000. No commercial trips would be allowed in the winter.

Analysis. Four launches per day would be allowed in the summer, two per day in the shoulder seasons, and one per day in the winter. This would even out launch patterns and reduce crowding at major attraction sites. This action would have localized, beneficial, short- to long-term, seasonal, minor effects on soils from current conditions. Total summer user-days would decrease, which would have minor benefits to soils, and use would be spread into the spring and winter. Spring use would be slightly higher than current, and winter use would double. Since winter is not a critical time for soils, this reallocation of user-days from summer to winter would be beneficial to soil resources and the protection of biological soil crusts. Reducing group sizes would also be beneficial to soils year-round, as smaller groups tend to spread out less than larger ones. Groups of 25 would be better able to utilize the more abundant medium-sized campsites,

with less probability of having to move into the old high-water zone to camp. Small noncommercial trips with groups of 8 could use small beaches with capacities of less than 12 people. A reduction in group size to 25 would have localized, beneficial, long-term, year-round, minor to moderate effects on soils from current conditions. Shorter trip lengths would require trips to move through the canyon faster, allowing less time for layover days and hikes to attraction sites and into uplands and side canyons. This would most likely reduce impacts to soils in these areas; however, parties would still use campsites nightly, and impacts to the shoreline and new high-water zone might not be reduced. A reduction in trip length from current conditions would have localized, beneficial, short- to long-term, seasonal to year-round, minor effects to soils in the old high-water zone and up side canyons.

Overall user discretionary time would increase due to the absence of short motor trips, but this would be balanced by smaller group sizes, shorter trip lengths, fewer trips and people at one time, and fewer passengers, so soil impacts would likely be reduced. The absence of motorized boats would eliminate one source of shoreline erosion. Not allowing helicopter use would eliminate blowing dust at Whitmore. These actions would have localized, beneficial, short-term, seasonal, minor effects from current conditions.

Mitigation of Effects. The beneficial effects of Alternative B would reduce the amount of mitigation required compared to Alternative A; however, the level needed would be similar to the level currently occurring. The level of mitigation would be reasonable and attainable. All of the mitigations listed under "Methodology for Analyzing Soil Impacts: Mitigation of Effects" section above should be employed, but levels of patrols, educational efforts, and rehabilitation staff would be similar to current levels. This level of mitigation would be reasonable and attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short to long term, seasonal to year-round, and minor to major. Cumulatively, the effects of alternative B, when combined with those other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative B would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Under Alternative B a beneficial change from current condition would be expected in all three hydrologic zones. Mitigation would still be required, although less than under Alternative A. Soil conditions in the new high-water zone could improve faster than in the old high-water zone, but neither zone would return to pre-use conditions. Fewer launches per day, a 10,000 person reduction in total number of passengers, smaller group sizes, shorter trip lengths, lack of motorized craft, reduced number of trips and people at one time would all be beneficial to soil resources. Effects in the shoreline zone would be short to long term, while resources in the old high-water zone would continue to experience long-term effects. Use would still be highest in the summer, even though more use would be spread into shoulder and winter seasons; however, changes to the other variables would result in an overall improvement to soil conditions.

Alternative B would have beneficial, localized, short- to long-term, year-round, minor to moderate effects on soils compared to current conditions. Compared to natural conditions, Alternative B would have adverse, localized, short- to long-term, year-round, minor to moderate effects. Alternative B would not result in the impairment of the soil resources in Grand Canyon National Park. Cumulative impacts, as described for Alternative A, would continue to be localized to regional, adverse, short to long term, year-round, and minor to major. Alternative B would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative C

Under Alternative C motors would be eliminated, maximum group size would be reduced to 30 people, and maximum trip length to 21 days. The number of trips and people at one time would be reduced, while total annual user-days would increase by around 100,000 (see Table 4-1). User-day levels would double in the shoulder seasons, as would total user discretionary time, with the greatest increase in the winter and shoulder seasons. Launches per day would be reduced to four in the summer and three in the shoulder seasons, but increased to two per day in the winter months. There would be approximately 3,000 more passengers per year. Commercial oar trips would be allowed in the winter.

Analysis. A reduction in group size to 30 would have localized, beneficial, long-term, year-round, minor effects on soils from current conditions in all three hydrologic zones, with a potential reduction in impacts from multiple social trails and use in the old high-water zone. Shortening trip lengths would require trips to move through the canyon faster, allowing less time for layover days and hikes to attraction sites and into uplands and side canyons. This would most likely reduce impacts to soils in these areas and have localized, beneficial, short- to long-term, seasonal to year-round, minor effects to soils in the old high-water zone and up side canyons from current conditions. However, parties would still use campsites nightly, and impacts to the shoreline and new high-water zone might not be reduced. Although launches per day would be managed, the high numbers of users traveling at the same speed would likely not improve crowding problems at attraction sites and would result in a negligible effect to soils from current conditions.

The increase in total annual user-days, user discretionary time, and total passengers would result in more feet on the ground over the course of a year. The repetitive use of campsites and more trail users would increase soil compaction and the potential for gullying to occur during rain storms. More use on the shoreline and in the new high-water zone would disturb more sediment year-round, increasing erosion. This would have localized, adverse, short- to long-term, seasonal to year-round, moderate to major effects on soils. The greatest increase in use would be in the winter, when soils are less susceptible to impacts, but total number of passengers would double in the spring during spring runoff when the potential for gullying increases and trampling of sprouting vegetation would decrease soil stability. Eliminating motor trips would remove one source of shoreline erosion, which would have a beneficial effect. Allowing no Whitmore helicopter exchanges would reduce the amount of blowing dust. Eliminating motorized uses would have localized, beneficial, short- to long-term, seasonal, minor effects on soils from current conditions.

Mitigation of Effects. Mitigations would be similar to those described in Alternative A except with a greater increase in staffing levels for patrols, educational efforts, and rehabilitation. In addition, new staffing would be needed in the spring and winter months. A considerable increase in funding would be needed. This level of increased mitigation may not be reasonable or attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short to long term, seasonal to year-round, and minor to major. Cumulatively, the effects of alternative C, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative C would result in a localized, adverse, short- to long-term, seasonal to year-round, minor to moderate contribution to these cumulative effects.

Conclusion. Reducing group size would have substantial beneficial effects to soils in all three hydrological zones by reducing the potential for multiple trail creation, biological soil crust damage, and camping impacts in the old high-water zone. Reducing trip lengths would benefit uplands and side canyons. A substantial increase in total numbers of users and user discretionary time would increase soil compaction and erosion impacts, adversely affecting soils. Eliminating motors and reducing summer use while increasing winter use would be beneficial to soils. Doubling shoulder season use would have an adverse effect on soils. Adverse impacts to soils would be perceptible and measurable, and extensive mitigation would be necessary to reduce soil impacts. Local mitigation efforts would likely be successful, but would not reduce impacts down to minor levels. Impacts to the shoreline would be short to long term, while impacts in the old high-water zone would be long term. Impacts to all three zones would be year-round.

Alternative C would have beneficial, localized, short- to long-term, year-round, minor effects on soils compared to current conditions (Alternative A). Alternative C would have adverse, localized, short- to long-term, year-round, moderate to major effects on soils Alternative C would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would continue to be adverse, localized to regional, short to long term, and minor to major. Alternative C would result in a localized, adverse, short- to long-term, seasonal to year-round, minor to moderate contribution to these cumulative effects.

Alternative D

Alternative D is a mixed-use alternative, with eight months of motor use and four months of no-motor use in the shoulder seasons to coincide with the high backcountry use season. Maximum commercial group size would be 25 people. Trip lengths would be reduced in the summer and shoulder seasons, but a maximum trip length of 30 days would be allowed in the winter. An eight-person noncommercial trip would be added. Total annual user-days would increase by about 50,000 (see Table 4-1). This alternative would have the highest total user discretionary time. The number of trips and people at one time would be reduced from current levels. There

would be no Whitmore helicopter exchanges. Commercial motor and oar trips would be allowed in the winter.

Analysis. The reduction in group size to 25 would have localized, beneficial, long-term, year-round, minor to moderate effects on soils from current conditions in all three hydrologic zones. Smaller groups could utilize more abundant medium-sized beaches, with less potential for camping impacts in the old high-water zone. Shorter summer and shoulder season trip lengths would benefit soils during the critical months by reducing layover days and opportunities for hiking into the uplands and side canyons. This would have localized, beneficial, short- to long-term, seasonal to year-round, minor effects to soils from current conditions and would most likely reduce impacts to soils in these areas. However, parties would still use campsites nightly, and impacts to the shoreline and the new high-water zone might not be reduced.

Longer winter trips would occur when soils are less susceptible to erosion impacts. Allowing five launches per day in summer, three per day in the shoulder seasons, and one per day in winter would be greater than under Alternative B, but trips would be shorter. No-motor use in the spring would have localized, beneficial, short- to long-term, seasonal, minor effects on shoreline soils by reducing erosion caused by wakes during spring. This alternative would have the highest summer user discretionary time, but smaller group sizes would help reduce the likelihood of multiple social trail creation and impacts to biological soil crusts. With shorter trip lengths, use would be concentrated at sites along the river, resulting in a possible minor beneficial effect on tributary soils. The increase in total user-days would mean more people walking on the soils, which would increase soil compaction and erosion impacts and result in localized, adverse, short- to long-term, year-round, moderate impacts. Not allowing helicopter exchanges would eliminate dust generation at Whitmore and would have minor beneficial effects.

Mitigation of Effects. Mitigations would be similar to those described for Alternative A except staffing levels would increase above the levels needed in A, but not as high as under Alternative C. The increase would be reasonable and attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short to long term, seasonal to year-round, and minor to major. Cumulatively, the effects of alternative D, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative D would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Alternative D would have beneficial effects to soils (including biological soil crusts) in the new and old high-water zones compared to current conditions because of reduced group sizes, and shorter trips would benefit upland and side canyon soils. The high user discretionary time would mean more available time for visitors to move about the site, potentially increasing soil impacts in the old high-water zone. Soil compaction would continue to change the character of the soil. There would be a slight benefit to shoreline soils because no motor wakes would occur in the spring. Impacts to soils in the shoreline zone would be short to long term, while impacts in the old high-water zone would be long term. With increased use in

the winter and shoulder seasons, impacts would likely occur year-round. Increased use in the summer would increase soil impacts during a critical season. Impacts would continue to be perceptible and measurable, and mitigation would likely be successful given adequate funding and resources.

Alternative D would have beneficial, localized, short- to long-term, year-round, minor to moderate effects on soils compared to current conditions. Compared to natural conditions, there would be adverse, localized, short- to long-term, year-round, moderate effects. Alternative D would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would be adverse, localized to regional, short to long term, and minor to major compared to natural conditions. Alternative D would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative E

Alternative E is a mixed-use alternative, with equal periods of motor and no-motor use (October to March). Maximum commercial group sizes would be reduced to 30 people for motor trips and 25 people for oar trips. An eight-person noncommercial trip would be added. Maximum trip lengths in all seasons would be reduced from current levels (see Table 4-1). Helicopters at Whitmore would be allowed from April to September. The maximum number of trips and people at one time would be reduced compared to current conditions, while total annual user-days would increase by approximately 60,000. Six launches per day would be allowed in the summer, three during the shoulder seasons, and two in the winter. No commercial trips would be allowed in the winter.

Analysis. Reduced trip lengths and commercial group sizes would have localized, beneficial, long-term, year-round, minor effects on soils from current conditions by reducing hiking impacts in the uplands and side canyons and the probability of multiple trailing, biological soil crust trampling, camping impacts in the old high-water zone. Reducing the numbers of trips and people at one time, along with evening out launch patterns, would reduce impacts from crowding, having localized, beneficial, short- to long-term, seasonal, minor impacts to soils from current conditions. Six launches per day in the summer might cause more competition for campsites, but the new launch patterns would likely reduce congestion at attractions. Reducing the motor season to six months would eliminate motor wakes during the fall and winter, but not during the critical seasons, having a negligible effect. Dust generation from helicopters would be limited to six months of the year, having a negligible effect. The increase in user discretionary time and a 60,000 user-day increase, with a significant increase occurring in the spring, would likely increase soil compaction and erosion impacts, having localized, adverse, short- to long-term, year-round, moderate effects on soils.

Mitigation of Effects. Mitigations would be similar to those described in Alternative A except staffing levels would increase somewhat higher than Alternative D, but not as high as Alternative C. This level of mitigation would likely be reasonable and attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts:

Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short-term to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of alternative E, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative E would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Reduced group sizes would benefit soils in all three hydrologic zones. Increased user-days and user discretionary time would likely increase erosion and soil compaction in terms of more foot traffic and more use during spring. A six-month no-motor season would benefit shoreline soils. Soil compaction impacts would continue to change the character of the soil. Impacts to soils in the shoreline zone would be short to long term and year-round, while impacts in the old high-water zone would be long term and year-round. Impacts would continue to be perceptible and measurable, and mitigation would likely be successful given adequate funding and resources.

Alternative E would have beneficial, localized, short- to long-term, year-round, and minor effects on soils compared to current conditions. Compared to natural conditions, there would be adverse, localized, short- to long-term, year-round, moderate effects on soils. Alternative E would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would be adverse, localized to regional, short- to long-term, and minor to major. Alternative E would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative F

Alternative F is a mixed-use alternative, with equal motor and no-motor seasons (July through December). Daily launches would allow a maximum of six trips per day in the summer, four in the shoulder seasons, and two in the winter (see Table 4-1). Helicopter exchanges at Whitmore would occur only during the January to June motor season. Commercial winter trips would be allowed. Maximum commercial group size would be 30 people, and trip lengths would be reduced in all seasons. An eight-person noncommercial trip would be added. The maximum number of trips and people at one time would be reduced, while annual user discretionary time would increase, and the number of total passengers per year would rise by around 3,000.

Analysis. Reduced group sizes, trip lengths, launches per day, and a six-month no-motor season under Alternative F would have localized, beneficial, short- to long-term, seasonal to year-round, minor effects on soils from current conditions. Part of the no-motor season would occur during the critical summer months, and motorboat wakes would no longer be a source of erosion from July to December, having localized, beneficial, short- to long-term, seasonal, minor effects from current conditions. Reducing the number of trips and people at one time and evening out launch patterns would reduce impacts from crowding and would also have minor beneficial effects. Six launches per day in the summer would cause more competition for campsites, but the new launch pattern would likely reduce congestion at attractions. User-days would decrease in the summer, reducing impacts to soils during the early summer hot and dry months and the late summer monsoons, but they would almost double from current levels in the spring. Increasing use in the

spring months would increase the probability of impacts to soils during spring runoff, and trampling of sprouting vegetation would decrease soil stability. This would have localized, adverse, short- to long-term, seasonal, moderate effects on soils.

Mitigation of Effects. Mitigations would be similar to those described in Alternative E, but levels of mitigation necessary to reduce impacts to minor in the spring might not be reasonable or attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of alternative F, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative F would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Reduced group sizes would benefit soils in all three hydrologic zones and would reduce the probability of camping in the old high-water zone, biological soil crusts being trampled, and multiple trails being created. Reduced trip length would benefit soils in the old high-water zone, as well as upland and side canyon soils, by limiting layover days and long hikes. Increased user-days (total feet and spring season) and user discretionary time would have adverse effects on soils because of increased erosion and soil compaction. A six-month no-motor season, with summer months included, would benefit shoreline soils. Specified launch patterns and a reduction in the number of trips and people at one time would reduce soil impacts from crowding. Soil compaction impacts would continue to change the character of the soil. Impacts to soils in the shoreline zone would be short to long term and year-round, while impacts in the old high-water zone would be long term and year-round. Impacts would continue to be perceptible and measurable, and mitigation would likely be successful given adequate funding and resources.

Alternative F would have beneficial, localized, short- to long-term, year-round minor effects on soils compared to current conditions, and adverse, localized, short- to long-term, year-round, moderate effects on soils compared to natural conditions. Alternative F would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would be adverse, localized to regional, short to long term, and minor to major. Alternative F would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative G

Alternative G is a mixed-use alternative, with an eight-month motor season and a four-month no-motor season (September to December). Under this alternative, maximum group size for commercial motor trips would be 40 people, similar to current conditions (see Table 4-1). Commercial oar trips would have a maximum group size of 30 people. Maximum trip lengths would be reduced in all seasons compared to current conditions. Launch patterns would allow for

six trips per day to launch in the summer, five in the shoulder seasons, and two in the winter. Shoulder month launches would be the highest of all alternatives aside from Alternative A. Total annual user-days would grow by around 78,000, with a slight decrease during summer, doubling in the spring, and increasing tenfold in the winter. Trips at one time would decrease substantially, with a modest reduction in people at one time from current. User discretionary time would be the second lowest. This alternative would allow for an increase of around 6,000 passengers annually. Winter commercial use would not be allowed, and Whitmore helicopter exchanges would be allowed from January to August.

Analysis. Localized, adverse, short- to long-term, seasonal, moderate to major effects on soils due to large group sizes would be similar to those described in Alternative A, occurring in both the new and old high-water zones. Only 25% of the campsites along the river can accommodate groups of 36 or more people. Large groups using the more abundant medium-sized beaches, with capacities of 24 or fewer people, tend to spread out into the old high-water zone, damaging stabilizing vegetation and creating barren areas for tent sites. Larger groups hiking on upland terraces also tend to spread out more, creating multiple trails and trampling biological soil crusts.

Shorter trip lengths require trips to move through the canyon faster, resulting in less user discretionary time and reduced time for layover days and hikes into the old high-water zone, uplands, and side canyons. This would have localized, beneficial, short- to long-term, year-round, minor effects on soils from current conditions in the uplands, along tributaries, and at attraction sites; however, trips would still be camping each night and affecting shoreline and new high-water zone soils at campsites.

Reducing numbers of trips and people at one time and evening out launch patterns would reduce impacts from crowding, having localized, beneficial, short- to long-term, seasonal, minor effects from current conditions. Six launches per day in the summer would cause more competition for campsites, but the new launch patterns would likely reduce congestion at attractions. A decrease in user-days in the summer would be beneficial to soils, while an increase in the spring would be adverse. The repetitive use of campsites and increased number of total feet on trails would increase soil compaction impacts. More feet on the shoreline and in the new high-water zone would disturb more sediment, increasing erosion. Much of the increase in use would be in the winter, when soils are less susceptible to impacts, but the total number of passengers would more than double in the spring. Together these actions would have localized, adverse, short- to long-term, seasonal to year-round, moderate to major effects on soils. Wakes from motorboats would occur in both critical spring and summer seasons, and these effects would be localized, adverse, short- to long-term, seasonal, and minor to moderate.

Mitigation of Effects. Mitigations would be similar to those described in Alternative C, with the highest staffing levels of all of the alternatives for educational programs, law enforcement patrols, and trail maintenance and revegetation staff. This alternative would require the greatest increase in funding and resources. This increase would not be reasonable or attainable. Increased use with larger parties would most likely require more site closures.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in “Methodology for Analyzing Soil Impacts:

Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative G, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative G would result in a localized, adverse, short- to long-term, seasonal to year-round, minor to moderate contribution to this cumulative effect.

Conclusion. Adverse impacts to soils under Alternative G would occur due to large group sizes, increased user-days, motor wakes during critical months, higher number of launches per day in spring, and increased number of passengers. Reduced user-days in the summer would be beneficial to soils. Reduced trip lengths would be beneficial to side canyon and upland area soils. Soil compaction impacts would continue to change the character of the soil. Impacts to soils in the shoreline zone would be short-term to long-term, while impacts in the old high-water zone would be long-term. Year-round impacts are expected due to use being spread out throughout the year. Impacts would continue to be perceptible and measurable and mitigation measures to offset adverse effects would be needed, extensive and their success would not be guaranteed.

Alternative G would have adverse, localized, short- to long-term, year-round, minor effects on soils compared to current conditions. Compared to natural conditions there would be adverse, localized, short- to long-term, year-round, moderate to major effects on soils. Alternative G would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would be adverse, localized to regional, short to long term, and minor to major. Alternative G would result in a localized, adverse, short- to long-term, seasonal to year-round, minor to moderate contribution to this cumulative effect.

Alternative H (NPS Preferred Alternative)

Alternative H is a mixed-use alternative, with even motor and no-motor (September to February) seasons. This alternative would allow six trips to launch in the summer, three in the shoulder seasons and one in the winter. Summer maximum commercial group size would be 32 people, and shoulder seasons would be 24. No commercial trips would be allowed in the winter. An eight-person noncommercial trip would be added. Trip lengths would be reduced from current levels in all seasons. Whitmore helicopter exchanges would occur only in the summer months, but hiking exchanges would be allowed in the shoulder seasons. User-days for both commercial and noncommercial users would increase by about 37,000, with noncommercial user-days almost doubling. Total number of passengers would increase by around 4,000, and user discretionary time would increase in all seasons.

Analysis. Reduced group sizes would be beneficial to soils year-round, helping protect biological soil crusts, because smaller groups tend to spread out less than larger groups. Groups of 24 in the shoulder seasons would be better able to use the more abundant medium-sized campsites with less probability of moving into the old high-water zone to camp. Small noncommercial trips with groups of eight could use small beaches with capacities of less than 12 people. A reduction in group size would have localized, beneficial, short- to long-term, year-round, minor to moderate effects on soils from current conditions. Shorter trip lengths would

require trips to move through the canyon faster, allowing less time for layover days and hikes to attraction sites and into uplands and side canyons, and this would have localized, beneficial, short- to long-term, year-round, minor effects on soils from current conditions. This would most likely reduce impacts to soils in these areas; however, parties would still use campsites nightly and impacts to the shoreline and new high-water zone might not be reduced.

Reducing the numbers of trips and people at one time and evening out launch patterns would reduce impacts from crowding, having localized, beneficial, short- to long-term, seasonal, minor effects on soils from current conditions. Six launches per day in the summer would cause more competition for campsites, but the new launch patterns would likely reduce congestion at attractions.

Whitmore helicopter use would be reduced to the four summer months, decreasing dust generation, having minor beneficial effects. Hiking exchanges at Whitmore in the shoulder seasons would increase local impacts to soils in the Whitmore area due to increased use on trails that do not receive much use under current conditions. Group sizes of 24 during these months would help limit the potential for multiple trailing, biological soil crust trampling, and vegetation damage, but increased use of established trails would increase soil compaction and possibly gullying in the spring. Overall, the Whitmore Wash hiking component of this alternative would have localized, adverse, short- to long-term, seasonal, moderate effects on soils.

Mitigation of Effects. Mitigations would be similar to those described in Alternative A, with approximately the same increase in staffing levels over Alternative A as described for Alternative D. This increase would be reasonable and attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative H, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative H would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to this cumulative effect.

Conclusion. Reduced group sizes would benefit soils in all three zones and would reduce the probability of camping in the old high-water zone, biological soil crusts being trampled, and multiple trails being created. Reduced trip lengths would benefit soils in the old high-water zone, as well as upland and side canyon soils, by limiting layover days and long hikes. Increased user-days (total feet and spring season) and user discretionary time would have adverse effects on soils because of increased erosion and soil compaction. A six-month no-motor season would benefit shoreline soils. Specified launch patterns and a reduction in the number of trips and people at one time would reduce soil impacts from crowding. Soil compaction impacts would continue to change the character of the soil. Impacts to soils in the shoreline zone would be short to long term and year-round, while impacts in the old high-water zone would be long term and year-round. Impacts would continue to be perceptible and measurable, and mitigation would likely be successful, given adequate funding and resources.

Alternative H would have beneficial, localized, short- to long-term, year-round, minor effects on soils compared to current conditions, and adverse, localized, short- to long-term, year-round, moderate effects on soils compared to natural conditions. Alternative H would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would be adverse, localized to regional, short to long term, and minor to major. Alternative H would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to this cumulative effect.

IMPACT ANALYSIS — LOWER GORGE ALTERNATIVES

Alternative 1 (Existing Conditions)

River recreational use below Diamond Creek occurs in recreational opportunity spectrum Zones 2 and 3. Mixed use includes both commercial and noncommercial oar and motor trips from Lees Ferry continuing on to Lake Mead, noncommercial and HRR trips launching from Diamond Creek, noncommercial boaters traveling upriver from Lake Mead, pontoon boats and helicopter tours in the Quartermaster area, and jetboat upriver passenger takeouts and noncommercial boat tow-outs. Current maximum group size for HRR day trips is 100 people year-round, with an average launch of one per day. Overnight trips average one launch per week, with a maximum group size of 34. No additional campsites would be added, maintaining the current number of 15. There are two small floating docks in the Quartermaster area, and at least one make-shift docking facility near RM 262.5, with no additional docks proposed. For pontoon operations, passengers average 188 per day during the peak season and 160 during the non-peak season. Upriver travel is unlimited below Separation Canyon (RM 239.5). There are currently no kayak/canoe delivery trips.

Analysis. Very little recreational impact research has been conducted by Grand Canyon National Park staff between Diamond Creek and Lake Mead; however, the Hualapai Division of Cultural Resources (HDCR) documented recreational impacts to various traditional cultural properties in 2001 and 2002. Five of the properties evaluated in 2001 (Whitmore Canyon, Granite Park, Pumpkin Springs, Three Springs Canyon, and RM 223) had been affected from trailing and onsite camping, with impacts ranging from heavy to severe (HDCR 2002).

During the HDCR 2002 survey, human-caused impacts at Bridge Canyon were reported to be heavy, with modification of the campsite area, increased trailing, moderate to heavy vegetation clearing, and camping in the upper portions of the site. At Spencer Canyon the resource staff observed moderate to heavy human impacts from trailing in the new and old high-water zones, especially around the toilet area. At Travertine Falls there were also moderate to heavy impacts from trailing along the spring and up to the ledge, and also on the upstream side of the spring and in front of the falls. They also noted broken and damaged vegetation along the trail. The recommendation in 2002 was to obliterate the social trails to protect resources.

With the drop in Lake Mead water levels, silt banks and mud flats have become prevalent along the river's edge. Wakes from motorboats and jetboats contribute to erosion of these newly exposed deposits, changing gentle slopes to sharply cut banks, as shown in Photo 4-1 (Mengel, pers. comm. 2004). The Hualapai Tribe has been particularly concerned about the adverse

impacts caused by the wakes from the 40-foot-long jetboats equipped with 1,050-hp engines and traveling at high speeds (Christensen, pers. comm. 2004). Effects from wakes have regional, adverse, seasonal to year-round, short- to long-term, minor to moderate effects on soils. Human foot traffic from all types of trips using the lower gorge, also contributes to shoreline and new high-water zone erosion at popular campsites and attractions, as described under "Issues" above. At these sites heavy foot traffic between moored boats and the core of the site creates access trails and dislodges sand and silt downslope. Noncommercial and commercial groups spending more off-river time hiking side canyons contribute to foot traffic that dislodges soil along tributary streams and at seeps and springs, increasing alluvial erosion in valuable riparian habitats. This has localized, adverse, year-round, short- to long-term, minor to moderate effects on soils. Use occurs year-round, with noncommercial trips from Diamond Creek downriver becoming popular in the shoulder and winter seasons due to warmer temperatures. Soils are more sensitive to erosion during the hot, dry early summer months and during the summer monsoon season and spring runoff, when trails can become gullies as draining water follows the path of least resistance. With repeated use, these access trails can become entrenched, funneling additional sand down to the river, especially during rain storms. This has localized, adverse, seasonal, short- to long-term, moderate to major effects on soils. Foot traffic also roughens the surface in sand and silt area, increasing the effects of wind and water erosion. At current levels of helicopter use associated with river running activities, blowing dust occurs locally at helipads, but for eight hours a day. This has localized, adverse, year-round, short- to long-term, minor to moderate effects on soils.

Under Alternative 1, peak-season group sizes of 100 on HRR trips would have the most detrimental localized effects on soils. Large groups walking the same trails day after day compact soil substrates along the trail. This has localized, adverse, year-round, short- to long-term, moderate to major effects on soils. Multiple trails are often created when members of parties leave the main established trail and blaze new trails while hiking to portable toilets and attractions or while exploring the old high-water zone. Multiple trails are more likely to form on the flat terraces in the Lower Gorge since it is easier for users to spread out in open areas. Larger groups are also more likely to disturb larger areas (Hendee, Stankey, and Lucas 1990).

Erosion due to Glen Canyon Dam operations and fluctuating and experimental flows is less of an impact on beaches in the Lower Gorge than in the Lees Ferry to Diamond Creek stretch. Currently, campsites in the Lower Gorge are becoming overgrown with exotic species of plants. Alternative 1 would continue to allow camping at existing beaches without NPS vegetation manipulation or specific designation of HRR overnight trip campsites on the left bank. River running parties currently attempting to use these overgrown beaches haphazardly cut vegetation to expand the sites and blaze multiple trails, which has localized, adverse, year-round, short- to long-term, moderate effects on soils.

Alternative 1 would allow for two small floating docks in the Quartermaster area. These docks have localized, beneficial, year-round, short- to long-term, minor effects to soils, limiting the amount of erosion impacts created from moored boats at RM 262 to 263. Passengers on Hualapai/OTI helicopter and pontoon boat trips would continue to compact soils on established trails at RM 262.5, walking from the helicopter pad to the pontoon boats. Although passengers are encouraged to stay on established, well marked trails, numerous multiple trails are present in

the area due to boat operators walking to and from stored fuel caches (Shearin, pers. comm. 2004).

Mitigation of Effects. To mitigate adverse effects, all of the actions listed in the "Methodology for Analyzing Soil Impacts: Mitigation of Effects" section above should be implemented. To attempt to reduce impacts to minor levels, a substantial increase in the number of NPS staff would be needed to educate users about soil impacts, to patrol campsites to ensure that river runners did not camp in the old high-water zone, and to revegetate barren areas and block undesirable multiple trails. This level of increase would likely not be attainable.

In addition, the Hualapai Tribe has considered developing a visitor management plan to address use patterns at heavily used sites, such as Diamond Creek, Quartermaster, and Travertine Falls. In cooperation with the Hualapai Tribe, the National Park Service should develop limits of acceptable change thresholds, which would trigger mitigations and management actions at all Lower Gorge sites. A cooperative monitoring and site rehabilitation program should be initiated. The Hualapai Tribe is considering plans to address dust abatement, gasoline storage, human waste disposal, and use restrictions at Travertine Canyon. They have also proposed that HRR boatman monitor client activities so that natural resources are not impacted by visitors.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative 1, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative 1 has a localized, adverse, short- to long-term, seasonal to year-round, moderate contribution to these cumulative effects.

Conclusion. Direct, localized, adverse, year-round, short- to long-term, moderate to major impacts would continue to occur to soils at specific sites in the Lower Gorge as a result of large group sizes using sites on a daily basis. Heavy impacts, including soil compaction, mineral soil exposure, and denuded vegetation resulting in barren cores, would continue at specific high-use sites. Boat wakes from motorboats and jetboats have a major impact on the riverbank from Lake Mead up to Separation Canyon (in Zone 3) due to the high number of powerboat users, higher horsepower motors, and faster travel speeds. Similar to the upper stretch, some impacts in the shoreline zone are short-term, while impacts in the new high-water zone and the more stable old high-water zone are long term (biological soil crust trampling, native vegetation damage leading to barren cores and destabilized soils). Use and resulting impacts occur year-round. Pontoon boat tours also run throughout the year. Blowing dust from helicopter use associated with river running activities would continue throughout the year. Under Alternative 1 mitigation measures to offset adverse effects at heavily used sites would be needed, extensive, and their success would not be guaranteed.

Alternative 1 would have adverse, localized to regional, short- to long-term, year-round, moderate to major effects on soils compared to natural conditions, but the continuation of present impacts under Alternative 1 would have negligible effects. Alternative 1 would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative impacts to soils would

continue to be adverse, localized to regional, short to long term, and minor to major. Alternative 1 has a localized, adverse, short- to long-term, seasonal to year-round, moderate contribution to these cumulative effects.

Alternative 2

Under Alternative 2 recreational use would be reduced to the lowest levels of any Lower Gorge alternative. For HRR day trips the maximum group size during the peak season would be 30, down from 100 people now. There would be two HRR day trip launches per day during the peak season and one per day during the rest of the year. Overnight HRR trips would have a slightly smaller group size than now, down to 30 from 34, with one launch per day, and the total number of daily passengers would be 48 in the peak season and 24 in the non-peak season, compared to 80 passengers per day year-round currently. One additional campsite would be created, requiring some vegetation removal. There would be no docks at Quartermaster. Pontoon boat tours and their associated helicopter shuttles would be eliminated. All upriver travel would be restricted to the section of river below RM 262, including jetboats per day to pick up commercial passengers.

Analysis. Smaller group sizes and fewer total people per day would have localized, beneficial, year-round, short- to long-term, moderate benefits to soils from current conditions in all three hydrologic zones. A reduction in the number of people per HRR day trip during the critical summer season would have localized, beneficial, seasonal, short- to long-term, minor to moderate effects on soils from current conditions. Although overnight trip launches would increase from one per week to one per day, the trips would use a designated campsite on the left riverbank, and group sizes would be more manageable. Vegetation removal would occur in the new high-water zone at the new campsite, which would destabilize some soils, increase the barren core, and expose soils to human impacts. These impacts would be offset because HRR overnight groups could use the new high-water zone and not blaze trails and create tent sites in the old high-water zone.

Wakes from pontoon use would be eliminated, as well as the foot traffic on the trails at RM 262.5. There would likely be a decrease in the number of helicopter flights associated with river recreation at RM 262.5, which would reduce the amount of blowing dust in the area. These actions would have localized, beneficial, year-round, short- to long-term, minor effects on soils from current conditions. The removal of docks would require HRR boats to moor directly along the banks. This would increase erosion at these specific sites and have localized, adverse, year-round, long-term, moderate effects on soils from current conditions. Commercial jetboat pickup use would be reduced to two boats per day, and exchanges would occur at RM 262, farther downriver. This reduction would minimize jetboat wakes and would have localized to regional, beneficial, seasonal, short- to long-term, minor to moderate effects on soils from current conditions.

Limiting the number of nights that parties could camp to four nights in the peak season and five nights in the off-season would help spread out use and reduce competition and crowding at campsite and attraction sites. Reducing the number of parties at one time at specific sites would reduce the probability that groups would spread out into new areas, creating multiple trails and trampling biological soil crusts. Limiting the number of days that river runners could camp in the

Lower Gorge would also reduce soil impacts along tributaries and in side canyons, protecting the alluvial substrates in sensitive riparian areas. Together these actions would have localized, beneficial, year-round, short- to long-term, moderate effects on soils from current conditions.

Mitigation of Effects. Mitigations would be similar to those described in Alternative 1; however the level of NPS staffing required to reduce impacts to minor would be similar to current levels. This level of mitigation is both reasonable and attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative 2, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative 2 would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Overall, Alternative 2 would have beneficial effects to soils in the Lower Gorge compared to current conditions. Fewer total feet on the ground, smaller group sizes, fewer layover days, fewer jetboats, no pontoon boats, and possibly fewer helicopter flights would most likely improve soil conditions slightly. These actions would have both short- and long-term, year-round effects. The level of mitigation needed would be less than under Alternative 1.

Alternative 2 would have beneficial, localized to regional, short- to long-term, year-round, minor to moderate effects on soils, compared to current conditions under Alternative 1. Compared to natural conditions there would be adverse, localized to regional, short- to long-term, year-round, minor to moderate effects on soils. Alternative 2 would not result in the impairment of soil resources in Grand Canyon National Park. Cumulative effects would be adverse, localized to regional, short to long term, and minor to major. Alternative 2 would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative 3

Alternative 3 would allow a similar mix of recreational opportunities as current conditions, but at different levels. The maximum group size for HRR day trips would be 30 (compared to 100 people now). Three HRR day trip launches per day would be allowed during the peak season and two per day during the rest of the year. The maximum group size for overnight trips would be 30 (compared to 34 now), but two launches per day would be allowed. Two campsites would be created, requiring vegetation removal below the old high-water zone and supply storage. A small floating dock would be installed at RM 262.5 to accommodate five pontoon boats and two HRR boats. Pontoon tours in the Quartermaster area would be allowed to expand to up to 400 passengers per day, and associated helicopter use would increase accordingly. Four jetboat pickups would be allowed, with exchanges occurring at Separation Canyon. All four jetboats could deliver kayak/canoe trips upriver to RM 273.

Analysis. Smaller group sizes and fewer total people per day would have localized, beneficial, year-round, short- to long-term, moderate benefits to soils from current conditions in all three hydrologic zones. A reduction in the daily number of HRR passengers in the critical summer season would have localized, beneficial, seasonal, short- to long-term, minor to moderate effects on soils from current conditions. Although overnight use would increase from one trip per week to two per day, the trips would use designated campsites on the left riverbank, and group size would be more manageable. Vegetation removal would occur in the new high-water zone at the two new campsites below Separation Canyon, destabilizing some new high-water zone soils, increasing the barren core, and exposing soil to human impacts. However, the new campsites would allow HRR overnight groups to use the new high-water zone and not blaze trails and create tent sites in the old high-water zone.

Pontoon passenger numbers would be allowed to rise to 400 passengers per day, which would increase the number of pontoon trips motoring up and down river within a 2-mile stretch in the Quartermaster area. This would increase the amount of erosion created by pontoon boat wakes. Higher levels of foot traffic on trails at RM 262.5 would exacerbate soil compaction. The number of associated helicopter flights would substantially increase the amount of blowing dust in the Quartermaster area. With higher levels of pontoon use, additional fuel storage areas would be required, indirectly increasing the number of multiple trails leading to these new storage areas. All of these actions would have localized, adverse, year-round, short- to long-term, minor to moderate effects on soils at RM 262.5.

This alternative would allow one small floating dock at RM 262.5. This small dock would help eliminate erosion caused by HRR boats mooring directly along the riverbank. It would also eliminate foot-induced erosion to the riverbank that would otherwise occur if 400 pontoon passengers per day walked down the sandy slope to access the pontoon boats. The dock would have localized, beneficial, year-round, short- to long-term, minor to moderate effects to soils, but negligible effects from current conditions.

Commercial jetboat pickup use would be reduced from six to four boats per day, but exchanges would continue to be made at Separation Canyon. Fewer jetboats would reduce the effects of wakes on soil banks, but the boats would be allowed to travel farther upriver than under Alternative 2. This reduction would have localized to regional, beneficial, seasonal, short- to long-term, minor effects on soils from current conditions. Allowing overnight parties to camp only five nights in the peak season and eight nights in the off-season would help spread out use and reduce campsite and attraction site competition and crowding, but not as well as in Alternative 2. Allowing fewer parties at one time at specific sites would reduce the probability of groups spreading out into new areas, creating multiple trails, and trampling biological soil crusts. Limiting the number of days all types of river trips could camp in the Lower Gorge would also greatly reduce soil impacts along tributaries and in side canyons, protecting alluvial substrates in sensitive riparian areas. Reducing trip length would have localized, beneficial, year-round, minor to moderate effects on soils from current conditions. Depending on the group size, the four one-day kayak/canoe trips should not impact soils any more than existing uses. Since these users would be on the river most of the day, they would be less likely to impact side canyon soils. These kayak/canoe trips would likely have negligible effects on Lower Gorge soils.

Mitigation of Effects. Mitigations would be similar to those described for Alternative 1. The level of NPS staffing required to effectively carry out the mitigations and reduce impacts to minor would be slightly higher than under Alternative 1 due to the increase in pontoon passengers. However this increase would be reasonable and attainable..

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative 3, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative 3 would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Although smaller group sizes, fewer layover days, and fewer jetboat pick-ups would likely improve soil conditions at many sites compared to current condition, increased pontoon boat use and helicopter use would have adverse localized effects in the Quartermaster area. Regionally within the two Lower Gorge zones, impacts to soils would be adverse and minor to moderate, and mitigation would likely be effective given adequate funding and resources. Locally, around RM 262, impacts to soils would continue to be major.

Compared to Alternative 1, Alternative 3 would have localized to regional, beneficial, short- to long-term, seasonal to year-round, minor to moderate effects on soils. Compared to natural conditions, impacts would be adverse, localized to regional, short- to long-term, year-round, and minor to moderate. Alternative 3 would not result in the impairment of the soil resources in Grand Canyon National Park. Cumulative impacts to soils would be adverse, localized to regional, short to long term, and minor to major. Alternative 3 would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative 4 (NPS Preferred Alternative)

Alternative 4 is characterized by a redistribution of HRR operations in accordance with a consensus between the National Park Service and the Hualapai Tribe on levels of HRR use and other uses originating at Diamond Creek. This alternative represents the National Park Service's preferred lower levels of pontoon boat use than the current average. Under this alternative HRR group sizes and trip lengths would be reduced compared to current conditions, and upriver jetboat numbers would be below current levels.

The maximum group size for HRR day trips would be 40 people during peak season with a variable number of launches per day, but no more than 96 passengers total per day. Maximum group size would be reduced to 35 during the non-peak season, with two launches per day. This would reduce the maximum group size from current conditions of 100 people per trip. Overnight trips would also have a smaller group size than now, down to 20 from 34 during both the peak and non-peak seasons. There would be three HRR overnight trips per day in the peak season and one in the non-peak season. Three new campsites would be added, resulting in the removal of

exotic vegetation below the old high-water zone. All multiday trips in the Lower Gorge would be limited to three nights in the peak season and five nights the rest of the year. A floating dock would be installed at RM 262.5 to accommodate five pontoon boats and two HRR boats; all other makeshift docking facilities would be removed. Pontoon tours in the Quartermaster area would be capped at a maximum of 150 passengers per day. Four jetboat passenger pick-ups and all noncommercial raft tow-outs would be allowed; jetboats would only be allowed to travel upriver as far as RM 260 unless Lake Mead was at full pool, then the exchange would occur at Separation Canyon (RM 240).

Analysis. The reduction in HRR day-trip group size from 100 people to 40 would have localized, beneficial, year-round, short- to long-term, minor effects on soils from current conditions at both lunch stop and attraction sites; however, total number of HRR passengers would rise, increasing the total number of people per day visiting these sites. This would have localized, adverse, year-round, short- to long-term, minor to moderate effects on soils from current conditions. While these actions would reduce crowding and the potential for multiple trailing impacts, soil compaction might worsen. Use for HRR overnight trips would increase from about one launch per week to three launches per day, but the trips would be using three new designated campsites on the left riverbank, and maximum group size would be 20 people, so effects would likely be negligible from current conditions. Vegetation would be removed in the new high-water zone to create these three campsites. While nonnative vegetation removal would destabilize some soils in the new high-water zone, along with increasing the barren core and exposing soils to human-caused impacts, it would allow the HRR overnight groups to utilize the new high-water zone and not blaze trails and create tent sites in the old high-water zone.

Limiting the number of nights that parties could camp to three nights in the peak season and five nights the rest of the year would help spread out use and reduce competition and crowding at campsites and attraction sites, similar to Alternative 2. This would have localized, beneficial, year-round, short- to long-term, minor to moderate effects on soils from current conditions. Reducing the number of parties at one time at specific sites would decrease the probability that groups would spread out into new areas, create multiple trails, and trample biological soil crusts. Limiting the number of days all types of river trips could camp in the Lower Gorge would also greatly reduce soil impacts along tributaries and in side canyons, protecting alluvial substrates in sensitive riparian areas.

Pontoon passenger numbers would be capped at 150 per day, which could potentially keep helicopter flights associated with river use at RM 262.5 at current levels. This would limit the amount of dust blowing in the Quartermaster area to current levels. The amount of erosion created by pontoon boat wakes would be similar to now. This would have regional, adverse, year-round, short- to long-term, minor effects on soils. The impacts of foot traffic from passengers walking down from the helicopter pad to the pontoon boats at RM 262.5 would be similar to current conditions, so the localized impacts to soils in the Quartermaster area would be similar to Alternative 1.

This alternative would allow one floating dock at RM 262.5 that could accommodate five pontoon boats and two HRR boats. This dock would help eliminate erosion caused by HRR boats mooring directly along the river bank. It would also eliminate the foot-induced erosion that would occur to the riverbank if 150 pontoon passengers per day had to walk down the sandy

slope to access the pontoon boats. The dock would have localized, beneficial, year-round, short- to long-term, moderate effects to soils, but a negligible effect from current conditions. Commercial jetboat pickups would be reduced from six to four boats per day, and exchanges would occur at RM 260 unless Lake Mead was at full pool, when exchanges would occur at Separation Canyon (RM 240). Fewer jetboats would reduce the effects of wakes on soil banks, and limiting upriver travel to RM 260 would reduce erosion in the stretch of river from Separation to RM 260 (where the pontoon boats run). This would have regional, beneficial, seasonal, short- to long-term, minor to moderate effects on soils over current conditions.

Mitigation of Effects. Mitigations would be similar to those described for Alternative 1. The level of NPS staffing required to effectively carry out the mitigations to reduce impacts to minor would be higher than that described in Alternative 2, but lower than that described in Alternative 1. This increase would be reasonable and attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative 4, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative 4 would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Conclusion. Under Alternative 4 smaller group sizes and a cap on pontoon passenger numbers would have beneficial localized and regional (within Zone 3) effects on soils in all three hydrologic zones. Increasing the total number of day and overnight HRR passengers per day would adversely affect soils by increasing the total number of feet compacting soils on trails and dislodging sand in the new high-water zone. Use would occur year-round, with a slight reduction in total numbers in the winter. Increasing HRR use in the summer months would increase impacts during this critical season. Limiting pontoon and jetboat use would benefit the river banks, reducing wake-caused erosion. There would be short- to long-term impacts along the shoreline, while long-term impacts would occur in the old high-water zone. Reducing group size, limiting the number of days parties can camp, and removing new high-water zone vegetation would all be beneficial to soils in the old high-water zone. Mitigation to reverse impacts under Alternative 4 would be necessary, but given adequate funding and resources, would likely be successful.

Alternative 4 would have localized to regional, beneficial, short- to long-term, year-round, minor to moderate effects to soils, compared to current conditions under Alternative 1. Compared to natural conditions, there would be adverse, localized to regional, short- to long-term, year-round, minor to moderate effects on soils. Alternative 4 would not result in impairment of the soil resources of Grand Canyon National Park. Cumulative impacts would continue to be adverse, localized to regional, short to long term, and minor to major compared to natural conditions. Alternative 4 would result in a localized, adverse, short- to long-term, seasonal to year-round, minor contribution to these cumulative effects.

Alternative 5 (Hualapai Tribe Proposed Action)

Alternative 5 is characterized by a redistribution of HRR operations and represents a consensus between Grand Canyon National Park and the Hualapai Tribe on levels of HRR use and other uses originating at Diamond Creek. However, this alternative represents the Hualapai Tribe's proposed higher levels of pontoon boat use than the current average. Under this alternative, HRR group sizes and trip lengths would be at substantially lower levels than under current conditions, and upriver jetboat trips would be eliminated.

Alternative 5 would have exactly the same level of HRR use as described in Alternative 4, along with the creation of three additional campsites, requiring vegetation to be removed only below the old high-water zone. This alternative differs from Alternative 4 in that there would be a larger floating dock installed at RM 262.5 accommodating seven pontoon boats and two HRR boats. Pontoon tours in the Quartermaster area would be allowed to increase up to a maximum of 960 passengers per day, and associated helicopter use would also increase substantially. There would be no jetboat pick-ups, and noncommercial tow-outs would only travel upriver to RM 273. There would be no kayak/canoe upriver delivery.

Analysis. HRR use would be exactly the same as in Alternative 4, so impacts to soil resources would be similar to those described above. Pontoon passenger numbers would be allowed to increase to 960 passengers per day, which would likely increase the number of river-related helicopter flights at RM 262.5 to a little over 200 flights per day. Doubling the number of helicopter flights would substantially increase the amount of blowing dust in the Quartermaster area. Increasing the level of pontoon boat use and number of boats from five to seven would increase the amount of erosion created by pontoon boat wakes. Raising the number of daily passengers from an average of 188 people to 960 people would increase foot traffic on the trails at RM 262.5, exacerbating soil compaction. With higher levels of pontoon use, additional fuel storage areas would be required, which would indirectly increase the number of trails leading to new storage areas. All of these actions would have localized, adverse, year-round, short- to long-term, moderate to major impacts to soils in the Quartermaster area.

Limiting the number of nights that parties could camp in the Lower Gorge to three nights in the peak season and five nights the rest of the year would help spread out use and reduce competition and crowding at campsites and attractions, similar to Alternative 2. Reducing the number of parties at one time at specific sites would reduce the probability that groups would spread out into new areas, create multiple trails, or trample biological soil crusts. Limiting the number of days all types of river trips could camp in the Lower Gorge would also greatly reduce soil impacts along tributaries and in side canyons, protecting alluvial substrates in sensitive riparian areas. There would be no one-day kayak/canoe trips. This would have localized, beneficial, year-round, short- to long-term, minor to moderate effects on soils from current conditions.

This alternative would allow for one large floating dock at RM 262.5 that could accommodate seven pontoon boats and two HRR boats. This dock would help eliminate erosion caused by HRR boats mooring directly along the riverbank. It would also eliminate foot-induced erosion that would occur to the river bank from 960 pontoon passengers per day if they were required to walk down the sandy slope to get on the pontoon boats. The dock would have localized, beneficial, year-round, short- to long-term, minor to moderate effects on soils, but a negligible

effect from current conditions. Commercial jetboat pickups would be eliminated, which would stop the effects of jetboat wakes on soil banks and have regional, beneficial, seasonal, short- to long-term, minor to moderate effects on soils from current conditions within Zone 3.

Mitigation of Effects. Mitigations would be similar to those described in Alternative 1. The level of NPS staffing required to effectively carry out the mitigations and attempt to reduce impacts to minor levels would be significantly higher than current levels. This increase would not be reasonable or attainable.

Cumulative Effects. The impact ratings from individual past, present, and reasonably foreseeable actions are discussed above in "Methodology for Analyzing Soil Impacts: Cumulative Impacts." The impact rating from all cumulative actions is regional to localized, adverse, short- to long-term, seasonal to year-round, and minor to major. Cumulatively, the effects of Alternative 5, when combined with these other past, present, and reasonably foreseeable actions, would result in regional to localized, adverse, short- to long-term, seasonal to year-round, minor to major effects on soils. Alternative 5 would result in a localized, adverse, short- to long-term, seasonal to year-round, moderate contribution to these cumulative effects.

Conclusion. Under Alternative 5 smaller HRR group sizes and shorter trip lengths would have beneficial, localized and regional (within Zone 3) effects on soils in all three hydrologic zones. Increasing the total number of day and overnight HRR passengers would adversely affect soils by increasing foot traffic, compacting soils on trails and dislodging sand in the new high-water zone. Use would occur year-round, with a slight reduction in the total numbers in the winter. Increasing HRR use in the summer months would increase impacts during the critical season. Eliminating jetboat use would benefit the riverbanks, reducing wake-caused erosion. Substantially increasing pontoon boat passengers would have major localized effects on soils in the Quartermaster area. There would be short- to long-term impacts along the shoreline, and long-term impacts in the old high-water zone. Reducing group size, limiting the number of days that parties could camp, and removing vegetation in the new high-water zone would all be beneficial to old high-water zone soils. Effects to soil productivity, integrity, stability, or fertility in the Quartermaster area would be readily apparent and would substantially change the character of the soils. Extensive mitigation measures to offset adverse effects would be needed, and their success could not be guaranteed. At other sites in the Lower Gorge, mitigation measures would be necessary to offset adverse effects and would likely be successful given appropriate levels of funding and resources.

Compared to existing conditions under Alternative 1, Alternative 5 would have regional to localized, beneficial, seasonal to year-round, short- to long-term, minor to moderate effects on soils. Compared to natural conditions, there would be adverse, localized, short- to long-term, year-round, moderate to major effects on soils. Alternative 5 would not result in the impairment of the soil resources in Grand Canyon National Park. Cumulatively, impacts to soils would be adverse, localized to regional, short to long term, and minor to major. Alternative 5 would result in a localized, adverse, short- to long-term, seasonal to year-round, moderate contribution to these cumulative effects.

WATER QUALITY

ISSUES

Water quality, which is determined by the chemical, physical, and biological quality of ambient waters at any point in time, can be affected by gases, aerosols and particulates from the atmosphere, weathering and erosion of rocks and soils, solutes and precipitants that are products of biogeochemical cycles, and the introduction of contaminants from the cultural activities of humans (such as drinking, swimming or fishing). Often subtle changes in water quality can result in substantial changes in dependent aquatic flora and fauna. Water quality is also related to the health of dependent aquatic communities and the variety of human uses for specific water sources. Water quality impacts, such as pollution and contamination, are measured by the degree to which threaten to eliminate natural ecological attributes or human uses of water (e.g. recreation).

Specific issues related to impacts on water quality from recreational activities along the Colorado River were raised during public and internal scoping:

- Pollution from human personal-care products (introduced through swimming, bathing, and washing), camp waste (primarily food scraps) and human fecal waste that wash into tributaries, mainstem backwaters, and springs can affect water quality and the aquatic resources that depend on them.
- Motorboat use introduces contaminants such as hydrocarbons and burned and unburned fuel and motor oil.
- Recreation in tributary streams adversely affects water quality by changing stream channel geometry (which effects temperature and bank stability) and contributing to turbidity and sediment/habitat distribution.
- Grand Canyon National Park needs to have enhanced monitoring and treatment for pollutants and contaminants to reduce effects to drinking water and dependent ecosystems.
- Water sources, particularly seeps and springs, are extremely important to some Tribes, and should be protected from the impacts of visitation

GUIDING REGULATIONS AND POLICIES

The Clean Water Act (33 U.S.C. 1251 et seq.) provides the basis for the legal and technical mechanisms to protect and restore the quality of natural waters through the establishment of water quality standards (sec. 303(a)); the identification and restoration of quality-impaired waters (sec. 303(d)); and the management of point- and non-point source pollution (sec. 319 and 402). Point sources are managed through the national pollutant discharge elimination system (NPDES) permit program. Non-point sources of pollution are largely managed through voluntary programs that strive to incorporate Best Management Practices into the routine daily operation of the activity.

States are given a central role for the establishment of water quality standards and for the management of water quality. States administer the various provisions of the Clean Water Act in an integrated fashion under the oversight of the Environmental Protection Agency (EPA) and in compliance with EPA regulations. EPA regulations require that a water quality standard consist of the following three elements: (1) designating uses to be made of the water; (2) setting minimum narrative or numeric criteria sufficient to protect the uses, and; (3) preventing degradation of water quality through antidegradation provisions.

The antidegradation policy (40 CFR 131.12) is an important component of water quality standards, and has important management implications to most units of the National Park System. Antidegradation should not be interpreted to mean that "no degradation" can or will occur. Degradation may be allowed even in the most pristine waters for certain pollutants as long as it is temporary and short-term in nature. In most cases, human actions and activities that introduce pollutants that threaten to exceed ambient water quality standards are contrary to the NPS Organic Act and the park's enabling legislation.

Waterbodies that fail to comply with water quality standards are compiled by states into a list, commonly referred to as a "303(d) list," for submittal to the Environmental Protection Agency. The agency approves the list only if it meets applicable requirements. Waterbodies on an approved 303(d) list require the establishment of a total maximum daily load (TMDL), which specifies the amount of a particular pollutant that may be present in a waterbody, allocates allowable pollutant loads among sources, and provides the basis for attaining or maintaining water quality standards.

All management actions must be in compliance with Arizona and EPA water quality criteria for designated protected uses on the Colorado River and its tributaries (as per Arizona Official Compilation of Administrative Rules and Regulations Sec. R9-21-208). The public must be informed of situations where natural ambient levels pose human health risks. Management actions must also be performed to prevent or minimize alteration of the physical channel to maintain habitat requirements for aquatic organisms and to preserve its natural flow and temperature regime.

The NPS *Management Policies 2001* (NPS 2000d) direct park managers to understand, maintain, restore, and protect the inherent integrity of natural resources, processes, systems and values of the park. To the extent possible, the NPS allows natural processes, including the evolution of species, to control landscape and population level dynamics, assuming that all of the components of the natural systems remain intact. The preservation of fundamental physical and biological processes, as well as individual species, plant communities, and other components of naturally evolving ecosystems, is inherent in management direction. The National Park Service will maintain as parts of the natural ecosystems through:

- Preserving and restoring the natural abundance, diversities, dynamics, distributions, genetic and ecological integrity, and behaviors of native species and the communities and ecosystems in which they occur.
- Restoring native species in parks when they have been extirpated by past human-caused actions.

- Initiating the return of human-disturbed areas to natural conditions (or the natural trajectory), including the processes characteristic of the ecology zone.
- Minimizing human impacts on native species, communities, and ecosystems, and the processes that sustain them.
- Preventing the introduction of exotic species and removing established populations.
- Monitoring natural systems and human influences upon them to detect change and developing appropriate management actions.
- Protecting watersheds, as complete hydrologic systems, primarily by avoiding impacts to watershed and riparian vegetation, and by allowing natural fluvial processes to proceed unimpeded.
- Preserving, enhancing and restoring the natural and beneficial values of wetlands.

The "Grand Canyon National Park 2004 Commercial Operating Requirements" address impacts to water quality from visitation, as highlighted below:

- Cans, rubbish and other refuse may not be discarded in the water or along the shore of the river, in side canyon, on trials, along escape routes, or in any other portions of the canyon. All refuse material must be carried out.
- The use of soap is restricted to the mainstem of the Colorado River only. Use of soap in side streams or within 100 yards of the confluence of any side stream and the main river is prohibited.
- Each boat party must carry a washable/reusable toilet system capable of containing and removing solid human waste from the canyon. A washable/reusable toilet must be accessible during the day.
- Two-stroke motors, which emit high levels of hydrocarbons and leak burned and unburned fuel into the water, are not permitted. Cleaner burning four-stroke motors are the only boat motors allowed in the park.

The "Superintendent's Compendium" restricts some areas including the following tributaries, springs and seeps, to day use only:

- Little Colorado River confluence (river left-mile 60-65)
- Shinumo Creek (RM 109)
- Elves Chasm (RM 116.5)
- Deer Creek confluence (1/2 mile upstream or downstream on the north side of the river at RM 136)
- Columbine Falls (within 200 yards of the bay at RM 274.3)

MANAGEMENT OBJECTIVES FOR WATER QUALITY

The management objective for water quality for the *Colorado River Management Plan* is to manage river recreation use in a manner that minimizes adverse chemical, physical, and

biological changes to the water quality in the mainstem Colorado River, tributaries, seeps, and springs.

METHODOLOGY FOR ANALYZING EFFECTS TO WATER QUALITY

The general process for assessing impacts to the environment is discussed in the "Introduction" to Chapter 4. Impacts on water quality were analyzed using the best available data on ambient water quality status and trends, and the nature and behavior of the pollutants known to be associated with recreational river use. Evaluation of the potential impacts to water quality was based on regulatory information from the Environmental Protection Agency, the Arizona Department of Environmental Quality, and the Hualapai Tribe Natural Resource Department. Effects specific to water quality are characterized for each alternative based on the impact thresholds presented in this Section. In order to analyze the effect of each alternative on water sources, a map with locations of known water sources, as well as visitor stopping points (camp, lunch, and attraction sites) and other sensitive resources was created. Using data from the Grand Canyon River Trip Simulator program, including data on use intensity, staff identified areas of resource concern, in which concentrations of sensitive resources overlapped with visitor use areas. These data were used to predict levels and types of use and potential levels of visitor impacts for each alternative.

The overall impact rating depends upon the interaction of context, duration, timing, and intensity of each identified impact. Impacts to water quality could be negligible, minor, moderate, and major. Additionally, each alternative was evaluated to determine whether effects are direct or indirect.

Impact Thresholds

Intensity

Negligible — Chemical, physical, or biological changes to water quality due to recreational activities would not be detectable.

Minor — Adverse: Chemical, physical, or biological changes to water quality due to recreational activities would be detectable and would degrade water quality, but would be within historical baseline or desired water quality conditions.

Beneficial: Impacts would result in detectable improvements to water quality.

Moderate — Adverse: Chemical, physical, or biological changes to water quality due to recreational activities would be detectable, but historical baseline or desired water quality conditions would only be temporarily degraded.

Beneficial: Impacts would result in detectable improvements to water quality and overall achievement of desired water quality conditions.

Major — Adverse: Chemical, physical, or biological changes to water quality due to recreational activities would represent a significant degradation from historical baseline water quality conditions. Alterations could be long term.

Beneficial: Impacts would result in significant improvement in water quality. Impacts would result in improved water quality parameters affected by human use.

Context

Localized — Localized impacts would be to small areas such as tributaries, eddies, attraction sites, or springs.

Regional — Regional impacts would affect all or most water sources associated with the Colorado River as it flows through Grand Canyon National Park.

Duration

Short term — The impact would last less than one month.

Long term — The impact would last longer than one month.

Timing

Impacts to water resources may be time sensitive. For example, mainstem impacts are likely to be more pronounced during low volume discharge months. Summer is a period of low discharge, high recreational use, and peak water temperatures. Monsoon storms (summer-fall) and late winter storms can cause flooding that impacts water resources. Biotic communities associated with side canyon water sources are more vulnerable in the spring growing season.

Cumulative Impacts

Cumulative impacts on water quality were determined by combining the impacts of each alternative with other past, present, and reasonably foreseeable future actions (see the "Introduction" to Chapter 4 for detailed list of all actions). Actions that specifically affect water quality are:

Runoff / Flash Flooding — The primary impact from flash flooding is an increase in turbidity, which results in elevated bacteria counts. Flash floods and runoff also carry chemicals (e.g., from pesticides), pathogens (e.g., E. Coli, animal waste), and other contaminants (e.g., trash, byproducts from mining) from the surrounding region and further degrade water quality. The adverse affects from episodes of contamination can be localized to regional and minor to moderate, but relatively short term.

Effects from Glen Canyon Dam — Glen Canyon Dam fundamentally changed the character of the Colorado River in Grand Canyon from a flood-prone river with a wide range of water temperatures and sediment loads, to a dam-controlled flow with a narrow range of water temperatures and significantly reduced sediment. Currently, long periods of constant and/or low flows in the mainstem may contribute to build-up of contaminants in areas such as eddies. Under natural conditions, these pollutants would periodically be swept away. Overall, effects to water quality from the dam are localized to regional, minor to moderate, and long term.

Sewage Treatment Plant in Glen Canyon — Several outbreaks of gastrointestinal illness have occurred among river users since 1972. Recent outbreaks in 1994, 2000, and 2002 involved more than 300 persons (Higgins 2002). In 2002, specimens taken from afflicted individuals were positive for the enteric Norovirus, which originates only from humans. Samples collected from the mainstem near Lees Ferry and from the sewage treatment plant at Glen Canyon Dam also tested positive for the Norovirus. The study concluded that the virus may have come from the sewage treatment plant and spread to recreationists through consumption of contaminated Colorado River water. This potential impact to water quality is adverse, minor to moderate, short term and regional. Identification of mitigation measures is currently being conducted.

Impacts from Animals — Studies in Grand Canyon have suggest that levels of coliform bacteria, which often renders water unfit for drinking, were generally low in the mainstem except during flood episodes (Brickler et al. 1983). Fecal coliform to fecal streptococcus ratios generally suggest that the source of contamination appears to be from domestic livestock or wildlife (Mazzu 1995; Rihs 1995, 1996). Exceptions occur for very short durations at a small number of tributaries that experience heavy and seasonal visitation. Overall, effects to water quality from domestic livestock and wildlife are localized to regional, minor to moderate, and short term.

Other Recreationists — Anglers and backcountry users who access the river corridor also contribute to visitor impacts in the mainstem, tributaries, seeps and springs. Their effects are adverse, localized, negligible to minor, and short-term.

Mitigation of Effects

Reasonable mitigations for impacts to water quality under all alternatives include the following:

- Keep areas of new disturbance to a minimum (1 acre or less) and incorporate appropriate best management practices and stormwater pollution controls into maintenance, construction, operations, and land-use activities in order to reduce quantities of sediment, hydrocarbons, pesticides, nutrients and other pollutants entering surface waters.
- Initiate a program to regularly monitor levels of chemical and microbiological agents, particularly those associated with recreational use, in mainstem and tributary waters.
- If limits are exceeded by natural sources of contamination, prescribe educational efforts to inform the public of the hazards, health risks and preventative measures.
- If recreational use results in noncompliance with applicable standards for water quality, implement the following measures to reasonably mitigate effects:

  (1) *Education* — Inform the public of the hazards, health risks, and preventative measures.

  (2) *Closures* — Restrict or deny access to areas that routinely exceed water quality standards due to human activity and/or that pose a risk to human health and safety. Closures could be temporary.

  (3) *Change in Use Regulations* — Prohibit certain practices and make others mandatory.

Assumptions

General assumptions used for analysis of effects from each alternative are discussed in the introduction to this chapter. Assumptions that specifically relate to the alternatives considered in this document and their effect on water quality are presented below:

- Because there are no data to empirically differentiate impacts to water quality between guided and noncommercial trips, the assumption is made that all individuals, whether guided or private have an equal opportunity to affect, or be affected by, water quality.
- Impacts on water quality from recreational uses are highly localized and occur largely in the immediate vicinity of attraction sites including many tributaries, lunch stops, and campsites.
- Because bacteria adhere to sediments they are generally found in larger concentrations in sediments at the bottom of lake, rivers, and stream than in the overlying waters. However, when activities that roil substrates (stir up bottom sediments), such as wading, swimming and flash flooding, there is an increase in turbidity (suspension of sediments in water) that consequently results in elevated levels of bacteria.
- Variables that contribute to congestion (e.g., group size, trip length, number of passengers, and user discretionary time) contribute to higher concentrations of pollutants and contaminants in localized areas. However, the interaction of the all variables taken together must be evaluated as a whole
- Longer trips, by their nature, increase the amount of time visitors have to interact with the canyon environment. This increased time has the potential to allow greater interaction with water resources. This is particularly true for side canyons, as longer trips are designed to allow visitors opportunities exploration. Off-season hiking (shoulder and winter months) are more conducive to exploring side canyons, as the extreme heat of the summer precludes hiking too far from the river itself.
- Impacts to water quality are largely short term.
- The park's current "Commercial Operating Requirements" reduce impacts to water quality by addressing issues such as fuel storage, use of soaps in the river corridor and its side canyons, and containment and disposal of food and human waste. While the majority of visitors are conscientious about protecting water resources, a small percentage of visitors will ignore park regulations and engage in acts that degrade the resource.
- Regional impacts to water quality are not anticipated from recreational uses of the Colorado River because sources of pollutants are minor compared to the river's volume.
- Indirect impacts from water quality degradation in both the Colorado River and in tributaries and springs can be adverse for visitors, aquatic species and for nearby vegetation. Aquatic species and wetland vegetation can be adversely impacted by increases in turbidity, salinity, and/or nutrient levels. Pollutants, such as fuels or lubricants, can also adversely impact aquatic species and wetland vegetation. The health of visitors may also be impacted by poor water quality in the Colorado River and in tributaries and springs.

- Detailed analysis of the consequences of implementation of each alternative on the biotic communities that are associated with the Colorado River and its associated seeps and springs is presented in the Aquatic Resources section of Chapter 4.
- Drinking water quality standards that are exceeded naturally and not from human causes are beyond the scope of this impact analysis.
- While motorized trips contribute contaminates to the mainstem of the Colorado River, their effect on tributaries, seeps and springs is considered negligible.

IMPACT ANALYSIS — LEES FERRY ALTERNATIVES

The sections below describe the direct and indirect potential environmental effects of each of the alternatives on water quality. The overall impact would depend on the interaction of context, duration, timing, and intensity of the impact upon the resources. Sources of information used for the analysis are described in Chapter 3.

Alternative A (Current Conditions)

Analysis. Management of recreational use under Alternative A would continue to allow large group sizes with a maximum commercial group size of 43, long trips with a maximum winter trip length of 30 days, and spikes in trips at one time, people at one time, and daily launches (see Table 4-1). User-days would remain capped at current levels, which would result in approximately 22,500 passengers per year. Highest use occurs in the summer months and lowest use in the winter months. User discretionary time would be similar to current levels (the lowest of all the alternatives). This alternative would also allow for large group sizes, increasing the probability that a larger surface area will be impacted. Larger groups are more likely to disturb larger areas (Hendee, Stankey, and Lucas 1990). When several large groups visit attraction sites at the same time, the probability of impacting water quality magnifies and impacts such as increases in turbidity, bank erosion, dam building, introduction of contaminants, and trampling of aquatic and riparian species and habitat are more likely to occur. Whitmore exchanges would occur year-round and there would be a three month no-motor season in the fall. Both motor and oar commercial trips would be allowed in the winter

Impacts to water quality from recreation are primarily from direct contact between visitors and water sources. In the mainstem of the Colorado River, increases in turbidity (and the subsequent elevation of bacteria levels) are caused by recreational activities such as wading, swimming, and boat launching and docking near camp and attraction sites and lunch stops. The adverse effects of increased turbidity are short term. Recreational uses also impact water quality of the Colorado River by introducing pollutants in the form of personal care and cleansing products, human waste, and dishwater. The effects of these contaminants, the level of which are minute compared to the river's volume, generally dissipate as they are dispersed downriver. Generally, impacts to the river corridor from direct visitor contact are adverse, minor to moderate, very short term and highly localized. Under Alternative A these impacts are most noticeable in the peak season.

Impacts to the physical character of tributary and spring waters from recreational use are more visible than those on the Colorado River because of the relatively smaller volume of flow. Some

tributaries, seeps and springs are attraction sites (Saddle Creek, Little Colorado River, Royal Arch at Elves Chasm, Deer Creek, etc.) and often experience large numbers of daily visitors and visitors at one time. People exploring side streams bring chemical and biological contaminants that have the potential to degrade water quality. Disturbance of streambed sediments by waders and hikers increases turbidity and results in increased levels of suspended bacteria that have the potential to impact the health of visitors who ingest them. Direct adverse effects from visitor access to tributaries are minor to moderate and short-term, because sediments settle naturally after visitors leave the site and contaminants generally dissipate or wash out within one month. Longer periods of visitation caused by spikes in use in the summer season results in longer periods of turbidity.

Consultation with American Indian groups has indicated that water sources, especially seeps and springs, are extremely important. These groups have also reported impacts to seeps and springs that include redirection of water flow and accumulations of human waste, in addition to increases in turbidity and introduction of contaminants. These adverse affects are, short to long term, minor to moderate and highly dependent on accessibility from the river corridor.

Group size, trip length, maximum allowable launches per day, and trips at one time and people at one time in the summer season are at their highest in this alternative, indicating a higher probability of crowding at certain attraction sites. Due to erratic launch schedules, many of these variables regularly spike in the summer. User discretionary time, however, is relatively low, indicating that groups have less time for exploration and are interacting more with resources close to the river. During spikes in use, up to 9 groups can launch together, leading to congestion and crowding at attraction sites, some of which are water sources. During the summer season, the major attraction sites with aquatic features would experience numerous days (up to 75 in Havasu Creek) with more than 100 people visiting in a single day. Similarly, these sites would experience numerous days (up to 36 in Havasu Creek) with more than 150 people visiting in a single day (Table 4-6). This level of use results in localized increases in turbidity, as well as higher concentrations of contaminants, especially at attraction sites. Adverse effects to water quality from summer use are minor to moderate, short term, localized and highly dependent on accessibility from the river corridor.

Under this alternative, overall use levels as measured by user-days, total passengers and total user discretionary time in the winter and shoulder seasons are at or near the lowest levels for all alternatives (see Table 4-2). While these variables indicate some of the lowest levels of off-season use, they coincide with the highest allowable group sizes and trip lengths. Low use in the spring is beneficial to water resources, especially in the mainstem, but longer trip lengths that encourage layover days and allow people more time to hike further up tributaries, make tributaries more vulnerable to impacts. The probability of increasing turbidity and modifying stream channels increases with large groups of people with more time to hike further up tributaries. Impacts to water quality in colder winter months are negligible, as hikers generally avoid getting wet. Overall, effects to water quality from winter and shoulder season use are adverse, minor, short term, localized and highly dependent on accessibility from the river corridor.

TABLE 4-6: PREDICTED VISITATION LEVELS AT MAJOR ATTRACTION SITES WITH AQUATIC FEATURES, MAY—AUGUST

	Alternative							
	A	B	C	D	E	F	G	H
Days with 100+ Visitors								
Little Colorado River	28	0	1	11	0	0	0	0
Shinumo Creek	53	0	5	86	0	2	3	0
Elves Chasm	75	0	80	98	2	11	5	0
Deer Creek	66	1	64	109	12	4	8	0
Matkatamiba	4	0	48	3	0	0	0	0
Havasu Creek	79	0	73	102	11	0	4	0
Days with 150+ Visitors								
Little Colorado River	11	0	0	0	0	0	0	0
Shinumo Creek	14	0	2	11	0	0	0	0
Elves Chasm	18	0	8	30	0	1	0	0
Deer Creek	24	0	27	32	0	0	0	0
Matkatamiba	0	0	9	0	0	0	0	0
Havasu Creek	36	0	39	31	0	0	0	0

Under this alternative, motorized trips are permitted nine months of the year. Effects of recreational use on water quality of the Colorado River include gasoline and motor oil pollution from motorized watercraft. Before conversion from two-stroke to four-stroke motors (completed in 2001), it was estimated that approximately 5,750 pounds of petroleum residue, as measured by non-volatile suspended solids, entered the Colorado River annually (NPS 1979). The primary source was exhaust in the water, although leakage from gas tanks and accidental spills contributed pollutants as well. That amount, while seeming large, was too small compared to the volume of river flow to be measurable. The conversion to four-stroke motors is thought to have substantially reduced water pollution from exhaust. Tests conducted by the Canadian government's Environmental Technology Centre showed that four-stroke outboards discharged one-twelfth (8.3%) the amount of toxic hydrocarbons (benzene, toluene, ethylbenzene, and xylenes) as did two-strokes, and one-fifth (20%) the amount of oil and grease (Environment Canada 2000). While the impact of motors has decreased since conversion to four-stroke motors, some gasoline, oil, and grease still enter Colorado River water from marine motors. River dynamics and the large volume of the Colorado River diffuse and disperse these contaminants. Contamination can become more concentrated in backwaters and eddies, however. Motor use under this alternative results in localized adverse, short term, minor effects to the mainstem. This effect occurs throughout the entire motorized season, but is most pronounced during the high-use summer season.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), but because current management of the river corridor allows substantial spikes in use, as well as the longest allowable trip lengths and the largest group size of any of the alternatives, and because it does not include a focused management/mitigation plan, it is unlikely that that mitigations would be implemented at a level sufficient to reduce impacts to a minor intensity.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are

detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, minor to moderate and short term (because contaminants diffuse or dissipate in a short time period). Effects from the dam are longer term and regional.

Cumulatively, the effects of alternative A, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative A would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Recreational use under this alternative results in chemical, physical, and biological changes to water quality that are detectable and at times historical baseline or desired water quality conditions are altered. However, these effects generally diffuse or dissipate in a short time period. Thus, effects would continue to be adverse, minor to moderate, short-term, highly localized, and dependent on accessibility to the river corridor. Effects would continue to occur year-round, with most impacts during use spikes in the summer. Because current management of the river corridor allows substantial spikes in use, as well as the longest allowable trip lengths of any of the alternatives, it is unlikely that that mitigations would be implemented at a level sufficient to reduce impacts to a minor intensity. Alternative A would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of alternative A, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative A would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Alternative B

Analysis. Under Alternative B, recreational motor trips would be prohibited and group sizes, maximum daily launches, and probable total yearly passengers would be the lowest of any of the alternatives (see Table 4-1). Implementation of a launch-based system would eliminate spikes in use.

Summer use under this alternative would decrease from 121,869 total user-days currently to 107,418 and total passengers from 18,128 currently to 8,492. This, along with reductions in group size, trip length, trips at one time, and people at one time, would help reduce crowding and localized impacts to water sources (such as increases in turbidity or the introduction of contaminants). During the summer season, only one of the major attraction sites with aquatic features (Deer Creek) would experience any days with more than 100 people visiting in a single day. None of these sites would experience days with more than 150 visitors. This would be a substantial decrease from current conditions (Table 4-6). Shorter trip lengths, which reduce the accessibility of side canyon resources, would be somewhat offset by an increase in user discretionary time (from 294,506 hours currently to 431,444), which might result in increased interaction with all water resources, but to the less vulnerable mainstem waters in particular. Overall, summer use would have a beneficial, short-term, localized, and minor to moderate effect compared to current use.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-days, total passengers, and user discretionary time, would increase above current levels, but would be at much lower levels than the remainder of the alternatives. Compared to current use, these increases would result in greater interaction with water resources, but because these levels of off-season use would coincide with the lowest allowable group sizes and shorter trip lengths, and because visitors are less inclined to walk in tributaries during colder months, increased impacts would generally occur in the less vulnerable mainstem waters. The effects on water quality from off-season use would negligible and short term, compared to current use.

Under this alternative, motorized trips would not be permitted. This would result in a beneficial, short-term, localized, minor effect to the mainstem from current condition. This effect would occur throughout the year.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be needed primarily to mitigate new use in the winter and shoulder seasons. Use levels would generally be lower in the summer months, with the exception of user discretionary time. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, short term, localized, and minor to moderate (because contaminants diffuse or dissipate in a short time). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative B, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative B would result in an adverse, short-term, negligible, contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative B would directly reduce potential impacts to water quality, especially those in the mainstem. This would represent a beneficial, localized, minor to moderate effects that would be localized and dependent on site accessibility. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, but generally within historical baseline or desired water quality conditions. These changes would be short term and highly localized. Thus, most of the effects from visitation would be direct, adverse, localized, minor to moderate, and highly dependent on accessibility from the river. Effects would continue to occur year-round, with most impacts during summer when greater user discretionary time would offer additional opportunities for visitors to access water resources. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. Alternative B would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative B, when combined with

other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effects to water quality. Alternative B would result in an adverse, short-term, negligible contribution to these cumulative effects.

Alternative C

Analysis. Under Alternative C, recreational motor trips would be prohibited. Group sizes and trip lengths would be at lower levels than current, but probable total user-days and user discretionary time would be the highest of any of the alternatives (see Table 4-1). Probable yearly passengers would increase from 22,461 currently to 25,228. Implementing a launch-based system would eliminate spikes in use.

Summer use under this alternative would represent a decrease in total user-days (down to 110,120 from 121,869 currently) and total passengers (down to 11,252 from 18,128). This, along with moderate reductions in group size, trip length, trips at one time, and people at one time, would serve to lessen crowding, thus reducing localized impacts to water resources. These variables would be somewhat offset, however, by an increase in user discretionary time from 294,506 hours currently to 335,089, which might result in increased accessibility to all water resources, particularly tributaries, seeps, and springs. While user discretionary time could represent an increase in excursions per trip that river runners visit, it could also represent an increase the amount of time that visitors spend at fewer sites. During the summer season, the major attraction sites with aquatic features would experience numerous days (up to 80 in Elves Chasm) with more than 100 visitors in a single day. Similarly, these sites would experience numerous days (up to 39 in Havasu Creek) with more than 150 visitors in a single day (Table 4-6). This would be a negligible change from current conditions (Table 4-6). Overall, summer use would have an adverse, short-term, negligible effect on localized effect on water quality compared to current use.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-days and total passengers, would increase considerably above current levels (Table 4-2) and in most cases would be the highest use of all the alternatives. Compared to current use, these increases would result in more opportunities for visitors to interact with water resources. This would be somewhat offset because these levels of off-season use would coincide with the lower allowable group sizes and shorter trips, and because visitors would be less inclined to walk in tributaries during colder months, increased impacts in winter would be generally occur in the less vulnerable mainstem waters. The effects on water quality from increases in shoulder and winter season use would be adverse, localized, short term, and minor to moderate compared to current use. Adverse effects would be primarily to side canyon water resources in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive.

Under this alternative, motorized trips would not be permitted. This would result in a localized, beneficial, short-term, minor effect to the mainstem from current conditions. This effect would occur throughout the year.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be needed primarily to mitigate new use in the winter and shoulder seasons. Use levels would generally be lower in the summer months, with the exception of user discretionary time, and key aquatic attraction sites would still experience high levels of daily use. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic livestock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, short term, and minor to moderate (because contaminants diffuse or dissipate in a short time). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative C, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative C would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative C would result in minor beneficial and minor to moderate adverse short-term localized effect to water quality. New adverse effects would be primarily in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, and times historical baseline or desired water quality conditions would be altered. However, these effects generally dissipate in a short time. Thus, effects are adverse, minor to moderate, short-term, highly localized and dependent on accessibility to the river corridor. Effects would continue to occur year-round, with most impacts occurring during the shoulder and winter months from substantial use increases. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. Alternative C would not result in impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative C, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative C would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Alternative D

Analysis. Under Alternative D, recreational motor trips would be permitted from May to August and from December to February. Group sizes and trip lengths would be lower than current, but user discretionary time would be among the highest of any of the alternatives (see Table 4-1). Probable yearly passengers would decrease from 22,461 now to 20,427, and probable total user-

days would increase from 171,131 now to 223,314. Implementing a launch-based system would eliminate spikes in use.

Summer use under this alternative would see a small increase in total user-days (to 122,739 from 121,869 now) and a large increase in total user discretionary time (to 461,641 hours from 294,506 now), but a decrease in total projected passengers (down to 13,765 from 18,128 currently). These numbers indicate that fewer people would have more time to interact with the environment, which might result in increased accessibility to all water resources, particularly tributaries, seeps, and springs. During summer the major attraction sites with aquatic features would experience numerous days (up to 109 in Deer Creek) with more than 100 visitors in a single day. Similarly, these sites would experience numerous days (up to 32 in Deer Creek) with more than 150 visitors in a single day. This would represent an overall increase in visitation from current levels (Table 4-6). Reductions in group size, trip length, trips at one time, and people at one time would somewhat offset impacts to localized water resources (such as increases in turbidity or the introduction of contaminants). Overall, summer use would have an adverse, short-term, localized, minor to moderate effect compared to current use. Adverse effects would be most noticeable in tributaries, seeps, and springs that are accessible from the river corridor.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-day, user discretionary time and total passengers, would increase above current levels (Table 4-2). Overall, allowable trip lengths would be reduced from current, except for non-commercial 30-day oar trips, which would remain the same. Compared to current use, these increases would result in increased interaction with water resources, but because these levels of off-season use would coincide with lower allowable group sizes, and because visitors are less inclined to walk in tributaries during colder months, increased impacts in winter would generally occur in the less vulnerable mainstem waters. Adverse effects from increases in shoulder season use would be most noticeable in side canyon water resources where new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Increased shoulder season use would have less effect on the less vulnerable mainstem waters. Compared to current use, the effects on water quality from increases in shoulder and winter season use would be adverse, localized, short to long term, and minor to moderate.

Motorized trips would be allowed for eight months of the year, as compared to nine months now. This change would be negligible.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be needed primarily to mitigate new use in the winter and shoulder seasons. Use levels are generally lower in the summer months, with the exception of user discretionary time and some key aquatic attraction sites would still experience spikes in daily use. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed, but sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river

related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative D, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative D would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative D would result in beneficial, minor impacts and adverse, short-term, localized, minor to moderate impacts to water quality. New adverse effects would occur primarily in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, and at times historical baseline or desired water quality conditions would be altered. However, these effects generally dissipate in a short time. Thus, effects would be adverse, short-term, highly localized, minor to moderate, and dependent on accessibility to the river corridor. Effects would continue to occur year-round, with most impacts occurring during the shoulder and winter months due to substantial use increases. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. Alternative D would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative D, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative D would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Alternative E

Analysis. Under Alternative E, recreational motor trips would be permitted April through September. Group sizes would be lower and trip lengths shorter than under current conditions, but user discretionary time would be among the highest (see Table 4-1). Probable yearly passengers would increase to 23,812 from 22,461 currently, and probable total user-days would increase to 237,183 from 171,131. A launch-based system would eliminate spikes in use.

Summer use under this alternative would decrease negligibly in total user-days (121,836 from 121,869 now), and total user discretionary time would increase to 373,761 hours from 294,506 currently, but total projected passengers would decrease (down to 15,230 from 18,128). These numbers indicate that fewer people would have more time to interact with the environment, which could result in increased accessibility to water resources. Increased accessibility could result in localized increases in turbidity, but because trip lengths would be relatively low, most effects would be concentrated in the less vulnerable mainstem waters. During the summer season, only three of the major attraction sites with aquatic features would experience any days with more than 100 visitors in a single day. Deer Creek would have the highest number of such

days (12), but this would be significantly lower than the highest level of visitation (79 at Havasu Creek) under current conditions. None of these sites would experience days with more than 150 people in a single day. This would be a substantial decrease from current conditions (Table 4-6). Reductions in group size, trip length, trips at one time, and people at one time would reduce crowding and impacts to localized water resources (such as increases in turbidity or the introduction of contaminants). Overall, summer use would have a beneficial, short-term, localized, negligible to minor effect compared to current use.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-days, user discretionary time, and total passengers, increase considerably above current levels (Table 4-2), but would be relatively low compared to some of the alternatives. Compared to current use, these increases would result in increased interaction with water resources, but because these levels of off-season use would coincide with the lower allowable group sizes and among the shortest allowable trip lengths, and because visitors are less inclined to walk in tributaries during colder months, increased impacts would generally occur in the less vulnerable mainstem waters. Adverse effects would be most noticeable in the side canyon water sources during the warmer shoulder seasons, especially in spring when dependent species are most vulnerable to trampling, turbidity, and contaminants. Overall, the effects on water quality from off-season use would be adverse, short term, and negligible to minor, compared to current use.

Motorized trips would be allowed for six months a year, as compared to nine months under current conditions. This would result in a minor beneficial change.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.) and would be needed primarily to mitigate new use in the winter and shoulder seasons. Use levels would generally be lower in the summer months, with the exception of user discretionary time. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative E, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative E would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative E would result in beneficial minor impacts and adverse short-term localized impacts to water quality. New adverse effects would be

primarily in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, and at times historical baseline or desired water quality conditions would be altered. However, these effects generally dissipate in a short time. Thus, effects would be adverse, short-term, highly localized, minor to moderate, and dependent on accessibility to the river corridor. Effects would continue to occur year-round, with most impacts occurring during the shoulder and winter months due to use increases. With mitigation could be reduced to a minor intensity. Alternative E would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative E, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative E would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Alternative F

Analysis. Under Alternative F, recreational motor trips would be permitted January through June. Group sizes would be lower and trip lengths shorter than under current conditions. User discretionary time would be higher than it is currently, but relatively low as compared to several other alternatives (see Table 4-1). Probable yearly passengers would increase from 22,461 currently to 25,415, and probable total user-days would increase from 171,131 currently to 235,146. A launch-based system would eliminate spikes in use.

Summer use under this alternative would represent a considerable decrease in total user-days (down to 102,291 from 121,869), total user discretionary time (down to 269,507 hours from 294,506 currently), and total projected passengers (down to 13,954 from 18,128). These numbers indicate an overall decrease in use. Additionally, reductions in group sizes, trip lengths, trips at one time, and people at one time would help reduce crowding and impacts, such as increases in turbidity and contaminants, to localized water resources. During the summer season, only three of the major attraction sites with aquatic features would experience any days with more than 100 people in a single day. Elves Chasm would have the highest number of such days (11), but this would be substantially lower than the highest level of visitation (79 at Havasu Creek) under current conditions. One site, Elves Chasm, would experience one day with more than 150 visitors in a single day. This would represent a significant decrease from current conditions (Table 4-6). Overall, summer use would have a beneficial, short term, localized, minor effect compared to current use.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-days and total passengers, would increase considerably above current levels (Table 4-2). Compared to current use, these increases would result in increased interaction with water resources, but because these levels of off-season use would coincide with the lower allowable group sizes and trip lengths, and because visitors are less inclined to walk in tributaries during colder months, increased impacts would generally occur in the less vulnerable mainstem waters. Adverse effects would be most noticeable in the side canyon water sources during the warmer shoulder seasons, especially in spring when dependent species are most vulnerable. Overall, the

effects on water quality from off season use would be adverse, short term, and minor, compared to current use.

Motorized trips would be allowed for six months of the year, as compared to nine months under current conditions. This change would result in a minor, beneficial impact.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be needed primarily to mitigate new use in the winter and shoulder seasons. By all counts, use levels are generally lower than current condition in the summer months. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative F, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative F would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative F would result in beneficial, minor impacts and adverse, short-term, localized impacts to water quality. New adverse effects would occur primarily in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, and at times historical baseline or desired water quality conditions would be altered. However, these effects generally dissipate in a short time. Thus, effects would be adverse, short-term, highly localized, minor to moderate, and dependent on accessibility to the river corridor. Effects would continue to occur year-round, with most impacts from use increases occurring during the shoulder and winter months. With mitigation, effects could be reduced to a minor intensity. Alternative F would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative F, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative F would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Alternative G

Analysis. Under Alternative G recreational motor trips would be permitted January through August. Group sizes would be somewhat lower than current, but higher than any of the other alternatives. Trip lengths would be generally at the lowest levels of all of the alternatives, except for noncommercial winter oar trips, which would still be reduced to 21 from 30 (current condition). Yearly user discretionary time would be higher than current condition, but would be at the lowest levels of all the other alternatives (see Table 4-1). Probable yearly passengers would increase to 28,680 from 22,461 currently, and probable total user-days would increase to 249,910 from 171,131. A launch-based system would eliminate spikes in use.

Summer use under this alternative would represent a considerable decrease in total user-days (down to 101,984 from 121,869 currently), total user discretionary time (down to 229,958 hours from 294,506), and total projected passengers (down to 14,939 from 18,128). These numbers indicate an overall decrease in use, particularly in the amount of time that visitors would have to interact with the environment and water resources, as represented by user discretionary time, which would be lower than any other alternative. This would be offset, however, by the large group size (40) for commercial motor trips. Because these large groups do not have sufficient time to access side canyon sites, it is anticipated that the impacts, such as increases in turbidity and contaminants, would generally be restricted to the most easily accessible sites along the river. During the summer season, four of the six major attraction sites with aquatic features would experience a few days with more than 100 visitors in a single day. Deer Creek would have the highest number of such days (8), which would be substantially lower than the highest level of visitation (79 at Havasu Creek) under current conditions. None of these sites would experience days with more than 150 people in a single day, a significant decrease from current conditions (Table 4-6). Compared to current use, summer use would have a beneficial, short term, localized, minor effect that would be highly dependent on accessibility from the river corridor.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-days and total passengers, would increase considerably above current levels and would be among the highest of all the alternatives.(Table 4-2). Additionally, winter launches would be twice those currently allowed, and shoulder launches, while reduced from current levels, would be higher than any other alternative. Compared to current use, these increases would result in greater potential interaction with water resources, but because these levels of off-season use coincide with shorter trip lengths and relatively low user discretionary time, and because visitors are less inclined to walk in tributaries during colder months, increased impacts would generally occur in the less vulnerable mainstem waters. Adverse effects would be most noticeable in the side canyon water sources during the warmer shoulder seasons, especially in spring when dependent species are most vulnerable. Overall, the effects on water quality from off-season use would be adverse, short term, and minor, compared to current use.

Motorized trips would be allowed for eight months of the year, as compared to nine months under current condition. This would be a negligible change from current conditions.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be needed primarily to mitigate new use in the winter and shoulder seasons. By all counts, use levels are generally lower

than current condition in the summer months. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative G, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative G would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative G would result in beneficial, minor impacts and adverse, short-term, localized impacts to water quality. New adverse effects would be primarily in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, and at times historical baseline or desired water quality conditions would be altered. However, these effects generally dissipate in a short time. Thus, effects would be adverse, short-term, highly localized, minor to moderate, and dependent on accessibility to the river corridor. Effects would continue to occur year-round, with most impacts from use increases occurring during the shoulder and winter months. With mitigation, effects could be reduced to a minor intensity. Alternative G would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative G, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative G would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Alternative H (NPS Preferred Alternative)

Analysis. Under Alternative H, recreational motor trips would be permitted from March through August. Group sizes would be lower than currently in the summer and considerably lower in the shoulder seasons. Trip lengths would be lower than current conditions, with some opportunities for longer trips in the winter. Yearly user discretionary time would be higher than current conditions, but lower than several other alternatives (see Table 4-1). Probable yearly passengers would increase to 26,317 from 22,461 currently, and probable total user-days would increase to 218,225 from 171,131. A launch-based system would eliminate spikes in use.

Summer use under this alternative would represent the highest level of user-days (125,243) and total projected passengers (18,132) of all the alternatives, including current conditions (121,869 user-days and 18,128 total passengers). These numbers suggest that summer use levels would be comparable to current condition, but user discretionary time would be relatively high (402,037 hours) compared to current conditions (294,506 hours) and several other alternatives. This indicates that visitors would have more time to interact with all water resources, particularly those in the side canyons. This would be somewhat offset, however, by reductions in group sizes, trip lengths, people at one time, and trips at one time, which would help reduce crowding and localized water resource impacts, such as increases in turbidity and contaminants. During summer none of the six major attraction sites with aquatic features would experience any days with more than 100 people in a single day. This would represent the lowest level of concentrated visitation at these sites and a substantial decrease from current conditions (Table 4-6). Overall, summer use would have an adverse, short term, negligible, and localized effect compared to current use. Effects would be most noticeable in tributaries, seeps, and springs.

Under this alternative, overall use levels in the winter and shoulder seasons, as measured by user-days and total passengers, would increase above current levels but would be among the lowest of all of the alternatives (Table 4-2). Group sizes in the off-seasons would be at the lowest level of all of the alternatives, with shoulder commercial trips reduced to 24 people (including guides) in the shoulder seasons. Compared to current use, these increases would result in increased interaction with water resources, but because these levels of off-season use would coincide with the shorter lengths and relatively low user discretionary time, and because visitors are less inclined to walk in tributaries during colder months, increased impacts would generally occur in the less vulnerable mainstem waters. Adverse effects would be most noticeable in the side canyon water sources during the warmer shoulder seasons, especially in spring when dependent species are most vulnerable. Overall, the effects on water quality from off-season use would be adverse, short term, and negligible to minor, compared to current use.

Motorized trips would be allowed for six months of the year, as compared to nine months under current conditions. This would be a minor beneficial change from current conditions.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be needed to mitigate new use in each season. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. With the exception of effects from the operation of Glen Canyon Dam, these effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period). Effects from the dam are longer term and regional.

Cumulatively, the effects of Alternative H, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative H would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

Conclusion. Compared to current use, Alternative H would result in beneficial and adverse, short-term, localized, minor effects to water quality. New adverse effects would occur primarily in the shoulder seasons when new use would increase opportunities for physical contact with water resources at a time when dependent biota are particularly sensitive. Chemical, physical, or biological changes to water quality due to recreational activities would still detectable, however, and at times historical baseline or desired water quality conditions would be altered. However, these effects generally dissipate in a short time. Thus, effects would be adverse, short-term, highly localized, minor to moderate, and dependent on accessibility to the river corridor. Effects would continue to occur year-round. With mitigation, effects could be reduced to a minor intensity. Alternative H would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative H, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative H would result in an adverse, short-term, negligible to minor contribution to this cumulative effect.

IMPACT ANALYSIS — LOWER GORGE ALTERNATIVES

Mitigation measures for the Lower Gorge alternatives include all of those stated for the Lees Ferry alternatives, plus the following:

- Develop a hazardous material plan for the transport and storage of petroleum in the Quartermaster area.
- Ensure that any federal and state regulations for the storage of petrochemicals are adhered to.
- Remove all petrochemical storage facilities from floodplains and riparian zone.
- Implement a monitoring and treatment program to collect baseline data, establish toxicity thresholds, and incorporate appropriate management actions to mitigate noncompliance with applicable water quality standards.

Alternative 1

Analysis. River recreational use below Diamond Creek includes commercial and noncommercial oar and motor downriver trips continuing to Lake Mead from Lees Ferry, noncommercial and HRR trips launching from Diamond Creek, private boaters traveling upriver from Lake Mead, Hualapai / Oriental Tour pontoon boats operating in the Quartermaster area, jetboats that run upriver for passenger takeouts, and noncommercial boat tow-outs. The maximum group size for HRR day trips is 100 people year-round; on average, one trip launches per day. Overnight trips average three launches per month and have a maximum group size of 34 (including guides). Pontoon operations average 188 passengers per day during peak season and 160 year-round. Commercial downriver trips continuing on to Lake Mead have a maximum group size of 43.

There are two small floating docks in the Quartermaster area for pontoon boat and HRR operations. Upriver travel is unlimited below Separation Canyon (RM 240).

Direct and indirect impacts to water quality in the Lower Gorge would be essentially the same as those identified under Lees Ferry Alternative A. Pollution from human personal care products, camp waste (primarily food scraps), motor fuel, and human fecal waste can wash into mainstem waters, tributaries, mainstem backwaters, and springs affecting water quality and the aquatic resources that depend on them. The intensity of the impacts varies, however, since the Lower Gorge is a different use zone in which the types and levels of use vary dramatically from the Lees Ferry to Diamond Creek portion of the corridor. The Lower Gorge is unique in that it is included in the 108 miles along the Colorado River that lies adjacent to Hualapai tribal lands. This land status has resulted in overlapping management by Grand Canyon National Park and the Hualapai Tribe. The Hualapai Tribe has a Lower Gorge water quality monitoring program in cooperation with the U. S. Geological Survey. Eighteen seeps and springs in the Lower Gorge that are significant to the tribe are monitored (Hualapai Tribe 2003). Use of the water sources includes aquatic and wildlife, full body contact, domestic, fish consumption, and agriculture (irrigation and livestock).

Under current management, HRR day trips generally launch one large trip per day from Diamond Creek, and passengers exit the river via helicopter at Quartermaster. According to the 2001 use moratorium, these trips can carry 80 passengers and 20 guides. While smaller trips are the norm, larger trips have been reported by Grand Canyon Resort Corporation and NPS river rangers. The greatest effect to water quality from HRR trips is from the impacts (the introduction of personal care products and human wastes, and disturbance of the substrate) caused by large groups coming in direct contact with localized water sources. These impacts, are generally restricted to Diamond Creek, Quartermaster, and lunch and attraction sites such as Travertine Canyon and Falls and Spencer Canyon. The springs at Diamond Creek, Spencer Canyon, Travertine Springs, and Travertine Falls are listed as outstanding tribal resource waters by the Hualapai Tribe (Hualapai Department of Natural Resources 2003). One of these water sources, Spencer Canyon Creek, is regularly monitored by the Hualapai Tribe. While visitor impacts are not quantified in the *2003 Water Assessment* (Hualapai Department of Natural Resources 2003), the report does identify litter, human waste contamination, fires, and unspecified water contaminants as potential problems associated with recreational use of the area. Large groups result in higher concentrations of contaminants in localized areas. Because access to water resources by day trips is generally restricted to the mainstem or immediately adjacent waters, contaminants diffuse quickly. Some contaminants can concentrate in eddies and backwater areas, however, resulting in localized degradation of water resources. This results in an adverse, short-term, minor to moderate effect that is highly dependent on the proximity to established HRR day trip stopping points.

HRR overnight trips generally occur once a week and carry 34 passengers, including crew. These motorized trips usually only spend one or two nights in the Lower Gorge before taking out by means of helicopter at Quartermaster (RM 262). Generally, these trips have a set itinerary and little time for passengers to explore side canyons. Thus, impacts such as increases in turbidity and contaminants are generally limited to the less vulnerable waters of the mainstem. Because these trips are short and infrequent, effects to water-quality are adverse, short-term, negligible to minor, and highly localized. This effect occurs almost exclusively in the high-use peak season.

All HRR trips are motorized and use four-stroke motors. While the impact of motors has decreased since conversion to four-stroke motors, some gasoline, oil, and grease still enter Colorado River water from marine motors. River dynamics and the large volume of the Colorado River diffuse and disperse these contaminants. Contamination can become more concentrated in backwaters and eddies, however. Motor use under this alternative results in adverse, short term, localized, minor effects to the mainstem. This effect occurs throughout the entire motorized season, but is most pronounced during the high-use peak season.

Noncommercial groups that launch from Diamond Creek have no time limits on their trips. Thus, access to water resources in the Lower Gorge is relatively unlimited. Although silt and thick nonnative vegetation make access to side canyons more difficult, longer trips allow visitors more opportunities to hike up tributaries and access sensitive springs and seeps. Group sizes are relatively small, however, which decreases crowding and localized impacts to water resources. Overall, private use has a direct, adverse, long-term, minor to moderate effect on localized resources. This impact occurs year-round.

Pontoon operations during peak seasons average 188 passengers per day, although daily spikes above 500 passengers have been documented. During the non-peak season (October to March), operators average 160 passengers per day. Six pontoon boats are located in the Quartermaster area, but only five boats are in operation at any one time. The pontoon tours generally last 20 minutes, with access and egress at the same location. Passengers on pontoon trips rarely have time for exploration, even in the direct vicinity of the helicopter pad and launch area. The pontoons generally take up to 10 passengers on each excursion, and the daily total for boat trips varies widely. Pontoon visitors have a negligible effect on the water quality, since they do not come into direct contact with the water because they embark and disembark via floating docks. Some gasoline, oil, and grease enter Colorado River water from the pontoon motors, but river dynamics and the large volume of the Colorado River diffuse and disperse these contaminants. Contamination can become more concentrated in backwaters and eddies, however. Motor use under this alternative results in localized adverse, short-term, minor effects to the mainstem. This effect occurs throughout the entire motorized season, but is most pronounced during the high-use peak season.

To support these pontoon operations, fuel is being stored in a containment basin. This fuel cache is within the riparian zone below the high-water mark at RM 262. It is estimated that at least 40–60 gallons of gasoline are currently stored in this location at any one time. Fuel is sling loaded via helicopter to the site from a Grand Canyon West facility. Boat/motor repair, including the disassembly of motors and lower units of the outboards, is also conducted at the dock site. This represents a substantial environmental contamination risk that could cause major, adverse, short- to long-term affects to the localized waters and habitat downriver.

Upriver commercial traffic consists of tow-outs (using four-stroke motors) and commercial passenger pick-ups (using jetboats) and is largely unlimited under this alternative. Use levels rarely exceed six trips per day, and given the dynamics and large volume of the Colorado River, contaminants from marine motors are quickly diffused and dispersed. Contamination can become more concentrated in backwaters and eddies, however. Motor use under this alternative results in adverse, short-term, localized, minor effects to the mainstem. This effect occurs throughout the entire motorized season, but is most pronounced during the high-use peak season.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), but because this alternative includes fuel storage hazards, large group sizes, unlimited trip lengths, and unregulated use, and because it does not include a focused management/mitigation plan, it is unlikely that that mitigations would be implemented at a level sufficient to reduce impacts to a minor intensity.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. These effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period).

Cumulatively, the effects of Alternative 1, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 1 would result in an adverse, short-term, minor contribution to this cumulative effect.

Conclusion. Overall, continued recreational use in the Lower Gorge under alternative 1 would result in chemical, physical, and biological changes that would be detectable, and desired water quality conditions would continue to be temporarily altered. However, unregulated use and current fuel storage practices associated with pontoon use represent a potential hazard that could significantly alter water quality conditions. Thus, Alternative 1 would result in adverse, localized, minor to major adverse effects that would generally be short term, but could reach the long-term threshold. These effects would be primarily in the peak season. Because this alternative includes fuel storage hazards, large group sizes, unlimited trip lengths, and unregulated use and because it does not include a focused management/mitigation plan, it is unlikely that mitigations would be implemented at a level sufficient to reduce impacts to a minor intensity. Alternative 1 would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative 1, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 1 would result in an adverse, short-term, minor contribution to this cumulative effect.

Alternative 2

Analysis. Under Alternative 2, group sizes, total number of daily passengers, and allowable upriver travel would be at the lowest levels of all alternatives (Table 4-3). Additionally, pontoon use and all associated operations and facilities would be eliminated.

Alternative 2 would allow two HRR peak-season day trips per day, each with up to 30 passengers, including guides. One trip of 30 people would be allowed during the non-peak season. Because the greatest current effect to water resources from HRR day trips use is from impacts such as increases in turbidity and contaminants caused by large groups, this alternative represents a direct, beneficial, short-term, negligible to minor effect from current condition at

localized water sources, particularly at Diamond Creek, Quartermaster, and lunch and attraction sites such as Travertine Canyon and Falls and Spencer Canyon.

HRR overnight trips could launch one trip per day, all year, and carry 30 passengers, including crew. It is unknown whether demand would eventually increase for this type of trip. Current trips are infrequent, but group size, trip length, and number of launches are unregulated. Thus, this alternative would provide for greater protection of water resources, should demand continue to grow. Overall, HRR overnight use would have a direct, beneficial, short-term, negligible to minor effect on water quality, compared to current conditions.

The number of private trips allowed to launch from Diamond Creek would remain unchanged, but trip length would be limited to four nights in the peak season and five nights in the non-peak season. This decrease in allowable trip length would limit access to sensitive tributaries, seeps, and springs. Group sizes would remain relatively small, decreasing the likelihood of crowding and its associated effects at attraction and camp sites. Compared to current conditions, private use would have a direct beneficial, long-term, minor to moderate effect on the quality of localized water sources.

Eliminating pontoon operations and associated fuel storage facilities would reduce the potential for a fuel spill or inundation, thus resulting in a beneficial, long-term, minor to moderate effect to water quality.

Upriver traffic under this alternative would be limited to two trips per day below RM 262. This reduction in allowable use would represent a beneficial, long-term, negligible to minor compared to current condition.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be necessary primarily to address effects from expansion of use into non-peak seasons. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. These effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period).

Cumulatively, the effects of Alternative 2, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative 2 would result in an adverse, short-term, negligible contribution to this cumulative effect.

Conclusion. Compared to current conditions, Alternative 2 would result in beneficial, short-term, localized, minor to moderate effects. Benefits would be derived primarily from reductions

in trip lengths and group sizes, regulation of use, and elimination of the pontoon fuel storage cache. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, but would generally be within historical baseline or desired water quality conditions. These changes would be short term and highly localized. Thus, most of the effects from visitation would be direct, adverse, localized, minor, and highly dependent on accessibility from the river. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. The effect would be year-round. Alternative 2 would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative 2, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to moderate effect to water quality. Alternative 2 would result in an adverse, short-term, negligible contribution to this cumulative effect.

Alternative 3

Analysis. Under Alternative 3, group sizes and trip lengths would be substantially lower than under current conditions. The total number of pontoon passengers, HRR passengers, and upriver trips would be near or above current levels(Table 4-3).

Alternative 3 would allow three HRR peak-season day trips per day, each with up to 30 passengers, including guides. Two trips of 30 people would be allowed during the non-peak season. Summer passenger totals would be comparable to current conditions, although smaller group sizes would substantially reduce localized water resource impacts such as increases in turbidity and contaminants from crowding. Winter use would allow for fewer passengers per day in addition to restricting group size. Overall, this alternative would represent a direct, beneficial, short-term, negligible to minor effect on localized water sources, particularly at Diamond Creek, Quartermaster, and lunch and attraction sites such as Travertine Canyon and Falls and Spencer Canyon.

HRR overnight trips could launch two trips per day, all year, and carry 30 passengers, including crew. It is unknown whether demand would eventually increase for this type of trip. Current trips are infrequent, but group size, trip length, and number of launches are unregulated. Thus, this alternative would provide for greater protection of water resources should demand continue to grow. Overall, HRR overnight use would have a direct, beneficial, short-term, and negligible to minor effect on water quality compared to current conditions.

The number of private trips allowed to launch from Diamond Creek would remain unchanged, but trip length would be limited to five nights in the peak season and eight nights in the non-peak season. This decrease in allowable trip length would limit access to sensitive tributaries, seeps, and springs. Group sizes would remain relatively small, decreasing the likelihood of crowding and its associated effects at attraction and camp sites. Compared to current conditions, private use would have a direct, beneficial, short-term, minor to moderate effect on localized water resources.

Pontoon operations would be limited to 400 passengers per day. While this level of use would be higher than the current average, it would be lower than the current spikes in use. Compared to

current conditions, pontoon use would have a direct, short-term, negligible effect on localized water resources in the Quartermaster area.

Boat/motor repair and the transport and storage of fuel create the potential for a fuel spill or inundation and thus would continue to represent a substantial environmental risk that could cause adverse, short- to long-term, major effects to the localized waters and habitat below RM 262.

Upriver traffic under this alternative would be limited to six trips per day below Separation Canyon. This use would represent a short-term, localized, negligible effect to water quality compared to current conditions.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be necessary primarily to address fuel transport and storage and the effects from expansion of use into non-peak seasons. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. These effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period).

Cumulatively, the effects of Alternative 3, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 3 would result in an adverse, short-term, minor contribution to this cumulative effect.

Conclusion. Compared to current conditions, Alternative 3 would generally result in beneficial, localized, short-term, minor to moderate effects. Benefits would be derived primarily from the regulation of use and reductions in trip lengths and group sizes. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, but would generally be within historical baseline or desired water quality conditions. These changes would be short term and highly localized. However, fuel storage practices associated with pontoon use would continue to represent a potential hazard that could significantly alter water quality conditions. Thus, most of the effects from visitation would be direct, adverse, localized, minor to major, and highly dependent on accessibility from the river. The effect would be year-round. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. Alternative 3 would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative 3, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 3 would result in an adverse, short-term, minor contribution to this cumulative effect.

Alternative 4 (NPS Preferred Alternative)

Analysis. Alternative 4 is characterized by a redistribution of HRR operations and represents a agreement between Grand Canyon National Park and the Hualapai Tribe on levels of HRR use and other uses originating at Diamond Creek. This alternative, however, represents the National Park Service's preferred lower levels of pontoon boat use than the current average. Under this alternative HRR group sizes and trip lengths would be at substantially lower levels than current conditions, and upriver trips would be below current levels (Table 4-3).

Daily passenger totals during the peak season would be limited to 96, with group sizes (including guides) not to exceed 40. No limits would be placed on trips per day in the peak season. This would allow HRR managers increased flexibility in scheduling launches, while encouraging the booking of smaller trips. Two trips of 20 people would be allowed during the non-peak season. Summer passenger totals would be somewhat higher than current condition, but smaller group sizes would reduce potential water resource impacts such as increases in turbidity and contaminants from crowding. Winter use would allow for fewer passengers per day, in addition to restricting group size. Compared to current conditions, this alternative overall would represent a direct, beneficial, long-term, negligible to minor effect at localized waters sources, particularly at Diamond Creek, Quartermaster, and lunch and attraction sites such as Travertine Canyon and Falls and Spencer Canyon.

HRR overnight trips could launch three trips per day in the peak season and one trip per day in the non-peak seasons and carry 20 passengers per trip, including crew. It is unknown whether demand would eventually increase for this type of trip. Current trips are infrequent, but group size, trip length, and number of launches are unregulated. Thus, this alternative would provide for greater protection of water resources should demand continue to grow. Overall, HRR overnight use would have a direct, beneficial, long-term, negligible to minor effect on water resources, compared to current conditions.

The number of private trips allowed to launch from Diamond Creek would remain unchanged, but trip length would be limited to three nights in the peak season and five nights in the non-peak season. This decrease in allowable trip length would limit access to sensitive tributaries, seeps, and springs. Group sizes would remain relatively small, decreasing crowding and reducing localized impacts to water quality. Compared to current conditions, private use would have a direct, beneficial, long-term, minor to moderate effect on localized resources.

Pontoon operations would be limited to 150 passengers per day. This level of use would be lower than the current average, and substantially lower than the current spikes in use. Compared to current conditions, pontoon use would have a direct, long-term, negligible effect on localized water quality in the Quartermaster area.

Boat/motor repair and the transport and storage of fuel create the potential for a fuel spill or inundation and thus would represent a significant environmental risk that could cause adverse, short- to long-term, major effects to the localized waters and habitat below the RM 262.

Upriver traffic in this alternative is estimated to be five trips per day in the peak season and two trips per day in the non-peak season. This use would be restricted to below RM 260 unless Lake

Mead is at full pool, then use would be s allowed to RM 240 (Separation Canyon). This use would result in a negligible effect to water quality compared to current conditions.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be necessary primarily to address effects from fuel transport and storage and expansion of use into non-peak seasons. A monitoring and treatment plan to determine and mitigate impacts from visitation would be needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. These effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period).

Cumulatively, the effects of Alternative 4, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 4 would result in an adverse, short-term, minor contribution to this cumulative effect.

Conclusion. Compared to current conditions, Alternative 4 would generally result in beneficial, localized, short-term, minor to moderate effects. Benefits would be derived primarily from the regulation of use and reductions in trip length and group size. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, but would generally be within historical baseline or desired water quality conditions. These changes would be short term and highly localized. However, fuel storage practices associated with pontoon use represent a potential hazard that could significantly alter water quality conditions. Thus, most of the effects from visitation would be direct, adverse, localized, minor to major, and highly dependent on accessibility from the river. The effect would be year-round. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. Alternative 4 would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative 4, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 4 would result in an adverse, short-term, minor contribution to this cumulative effect.

Alternative 5 (Hualapai Tribe Proposed Action)

Analysis. Alternative 5 is characterized by a redistribution of HRR operations and represents a consensus between Grand Canyon National Park and the Hualapai Tribe on levels of HRR use and other uses originating at Diamond Creek. This alternative, however, represents the Hualapai Tribe's proposed higher levels of pontoon boat use than the current average. Under this

alternative, HRR group sizes and trip lengths would be at substantially lower levels than current conditions, and upriver trips would be below current levels (see Table 4-3).

Daily passenger totals during the peak season would be limited to 96, with group sizes (including guides) not to exceed 40. No limits have been placed on trips per day in the peak season. This would allow HRR managers increased flexibility in scheduling launches, while encouraging the booking of smaller trips. Two trips of 20 people would be allowed during the non-peak season. Summer passenger totals would be somewhat higher than current conditions, but smaller group sizes would reduce potential water resource impacts such as increased turbidity and contaminants from crowding. Winter use would allow for fewer passengers per day in addition to restricting group size. Overall, this alternative would result in a direct, beneficial, long-term, negligible to minor effect at localized waters sources, particularly at Diamond Creek, Quartermaster, and lunch and attraction sites such as Travertine Canyon and Falls and Spencer Canyon.

HRR overnight trips could launch three trips per day in the peak season and one trip per day in the non-peak seasons and carry 20 passengers per trip, including crew. It is unknown whether demand would eventually increase for this type of trip. Current trips are infrequent, but group size, trip length, and number of launches are unregulated. Thus, this alternative would provide for greater protection of resources should demand continue to grow. Overall, HRR overnight use would have a direct, beneficial, long-term, negligible to minor effect on water resources, compared to current conditions.

The number of noncommercial trips allowed to launch from Diamond Creek would remain unchanged, but trip length would be limited to three nights in the peak season and five nights in the non-peak season. This decrease in allowable trip length would limit access to sensitive tributaries, seeps, and springs. Group sizes would remain relatively small, which would decrease crowding and reduce localized impacts to water quality. Compared to current conditions, private use would have a direct, beneficial, long-term, minor to moderate effect on localized resources.

Pontoon operations would be limited to 960 passengers per day. This level of use would be substantially higher than the current average, or any known spikes in daily use. Compared to current conditions, pontoon use would have a direct, adverse, long-term, minor effect on localized water resources at Quartermaster.

Boat/motor repair and the transport and storage of fuel create the potential for a fuel spill or inundation and thus would represent a significant environmental risk that could cause adverse, short- to long-term, major effects to the localized waters and habitat below RM 262.

Upriver traffic in this alternative would not be allowed above RM 273, except for pontoon traffic. This use would result in a beneficial, short-term, negligible to minor effect to water quality compared to current conditions.

Mitigation of Effects. Actions needed to mitigate effects would include all of those discussed above (monitoring, changes in regulations, education, etc.), and would be necessary primarily to address effects from fuel transport and storage and expansion of use into non-peak seasons. A monitoring and treatment plan to determine and mitigate impacts from visitation would be

needed and would be sufficient to reduce localized impacts to a minor intensity. Exact levels of mitigation would be determined based on the results of the monitoring program.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Cumulatively, domestic live-stock and wild animals, non-river related recreational use, flash floods, run-off, sewer treatment plant and dam operations, introduce chemical, physical, and biological changes to water quality in the area of effect that are detectable, and at times historical baseline or desired water quality conditions are altered. These effects are generally adverse, localized, and minor to moderate and short term (because contaminants diffuse or dissipate in a short time period).

Cumulatively, the effects of Alternative 5, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 5 would result in an adverse, short-term, minor to moderate contribution to this cumulative effect.

Conclusion. Compared to current conditions, Alternative 5 would generally result in beneficial, localized, minor to moderate impacts and adverse, short-term, minor effects. Benefits would be derived primarily from regulation of use and reductions in trip length and group size. Chemical, physical, or biological changes to water quality due to recreational activities would still be detectable, however, but generally within historical baseline or desired water quality conditions. These changes would be short term and highly localized. However, fuel storage practices associated with pontoon use represent a potential hazard that could significantly alter water quality conditions. Thus, most of the effects from visitation would be direct, adverse, localized, minor to major, and highly dependent on accessibility from the river. The effect would be year-round. Impacts to water quality could be reduced to a minor intensity with reasonable mitigation. Alternative 5 would not result in the impairment of water quality in Grand Canyon National Park. Cumulatively, the effects of Alternative 5, when combined with other past, present, and reasonably foreseeable actions, would result in an adverse, localized, short-term, minor to major effect to water quality. Alternative 5 would result in an adverse, short-term, minor to moderate contribution to this cumulative effect.

AIR QUALITY

ISSUES

External and internal scoping sessions identified several air quality issues related to river recreation:

- Air quality in Grand Canyon is generally good, but enough human-caused air pollution is present to affect various park resources (see the description in Chapter 3).
- Activities related to recreation on the Colorado River contribute to air pollution.
- Activities such as hiking, cooking and smoking generate some air pollutants, but not in significant amounts.

- Significant air pollution sources associated with recreational use of the Colorado River are motorized transportation, including outboard motors, helicopter shuttles, and jetboats.

- Campfire emissions also contribute to air pollution.

GUIDING REGULATIONS AND POLICIES

Air quality in Grand Canyon National Park is managed under the Clean Air Act, as amended, and implemented according to regulations issued by the Environmental Protection Agency and Arizona. Section 176(c)(1) of the act requires federal agencies to adhere to all applicable federal, tribal and/or state "implementation plans." Grand Canyon National Park is designated as a Class I area under the Clean Air Act, which allows very little deterioration in air quality. The act also includes an affirmative responsibility for the National Park Service to protect park resources from adverse impacts caused by air pollution, and requires the Service to adhere to applicable state regulations issued under the act. Under Section 165(d)(2)(B) "the Federal Land Manager and the Federal official charged with direct responsibility for management of such lands shall have an affirmative responsibility to protect the air quality related values (including visibility) of any such lands within a Class I area and to consider, in consultation with the administrator, whether a proposed major emitting facility will have an adverse impact on such values."

The Hualapai tribal lands are designated a Class II area under the Clean Air Act, which allows only moderate deterioration of air quality. Under no circumstances are conditions to violate the national ambient air quality standards established by the Environmental Protection Agency to protect human health and welfare. The Hualapai Tribe has been concerned about air quality on their lands, and has pursued redesignation of their lands as a class I area.

NPS *Management Policies* call for the agency to "assume an aggressive role in promoting and pursuing measures to protect these [park] values from the adverse impacts of air pollution. In cases of doubt as to the impacts of existing or potential air pollution on park resources, the Service will err on the side of protecting air quality and related values for future generations" (sec. 4.7.1).

In 1996 the Environmental Protection Agency issued its final rule for spark-ignited marine engines, including outboard motors (U.S. EPA 1996). This rule calls for manufacturers to phase in lower emission engines which will be completed by 2007. This conversion will be accomplished by replacing relatively dirty carbureted two-stroke engines with fuel injected two-strokes or four stroke engines. Although the four-stroke engines produced more nitrogen oxides (NO_x), their overall emissions and their contribution to ozone formation is substantially lower. All outboard motors used in the Grand Canyon are four-stroke engines and thus already meet these more stringent standards. The use of personal watercraft ("jet skis") is prohibited within the park (36 CFR 1.5, "Compendium of Designations, Closures, Use and Activity Restrictions, Permit Requirements and Other Regulations" September 1998).

MANAGEMENT OBJECTIVE FOR AIR QUALITY

Management objectives for the *Colorado River Management Plan* are included in Chapter 1. The objective for air quality is to ensure that exhaust emissions from river recreation-related craft do not degrade ambient air quality or adversely affect air quality related values, such as visibility, human and ecological health, and cultural resources.

METHODOLOGY FOR ANALYZING EFFECTS TO AIR QUALITY

The general process for assessing impacts to the environment is discussed in the "Introduction" to Chapter 4. Effects specific to air quality are characterized for each alternative based on the impact thresholds presented below. Additionally, each alternative was evaluated to determine whether effects would be direct or indirect.

Emissions were calculated for volatile organic compounds (VOC), carbon monoxide (CO), nitrogen oxides (NO_x), fine particulates less than ten micrometers in aerodynamic diameter (PM_{10}), and sulfur dioxide (SO_2). Outboard motor emissions were calculated for a four-stroke 30 horsepower gasoline engine operating at 21% load using emission factors were obtained from EA Engineering, Science, and Technology (2002). Table 4-7 summarizes outboard motor use trip variables applied to the different alternatives.

TABLE 4-7: OUTBOARD MOTOR TRIP VARIABLES

Trip Type	Motor Hours	Motors per Trip
Lees Ferry to Diamond Creek motor trips	54	1.6
Lower Gorge commercial (80% of trips)	12	1.6
Lower Gorge noncommercial (10% of trips)	12	1.6
HRR day trips	6	1
HRR overnight trips	12	1
Pontoon tours	0.33	1

Jetboat emissions for the Lower Gorge alternatives were calculated for the same pollutants except SO_2 assuming an average trip of two hours for jetboat tours and four hours for the tow-outs, using a single, 10-year-old, 725-horsepower marine diesel engine at 35% load and emission factors developed by the U.S. Environmental Protection Agency (US EPA 2002).

Aircraft emissions for Whitmore exchanges (Lees Ferry alternatives A, E–H) were calculated from one fixed-wing Dornier 288 aircraft making two flights per day, six days per week during the commercial season, and a Bell Jetrunner Helicopter making eight flights per day, six days per week during the commercial season, using the EDMS Modeling System (Heaton 2003; FAA 2002). Helicopter emissions at Quartermaster (all Lower Gorge alternatives) were calculated using a Bell Jetrunner helicopter within the EDMS Modeling System to simulate helicopter takeoffs and landings (see Appendix E).

Campfire emissions for the Lees Ferry alternatives were calculated based on one fire per trip per night during the winter, one fire every other night during the shoulder seasons, and no campfires during the summer. Each fire was estimated to consume 10 pounds of wood. Emission factors were derived from the park's 2000 microinventory (EA Engineering, Science, and Technology,

2002). Launches at Diamond Creek were calculated using the same method. However, due to different reporting methods, winter and shoulder seasons were not identified separately, so it was assumed there would be three campfires for every four non-summer nights spent camping per trip.

A table for each alternative shows emissions and the numbers of watercraft, aircraft, and campfires which form the basis for the emissions calculations. The numbers of watercraft, aircraft, and campfires were calculated by multiplying the expected number each day by the number of days to get a yearly total. In the case of aircraft, the number of aircraft is for helicopter shuttles of river passengers and is based upon the number of passengers allowed each day divided by five passengers per flight.

A calculation referred to as SUM06 (parts per million per hour) was used for evaluating the impacts of ozone. The highest three-month, five-year average commonly used for the area was determined by comparing ambient air quality data collected on the South Rim near Grand Canyon Village (available from the NPS Air Resources Division) to the Environmental Protection Agency proposed SUM06 level of 25 parts per million per hour (ppm/hr) that is associated with injury effects on vegetation.

Visibility impacts were determined by assessing particulate matter levels from local monitoring data, and from qualitative evidence such as personal observations and photographs.

Cumulative impacts were analyzed qualitatively and quantitatively. Emissions from river recreation were examined in the context of pollutant-specific monitoring conducted within the park and an emission microinventory of the park conducted for calendar year 2000 augmented with river-specific data (see Chapter 3). Wildland fire emissions were not considered for the analysis, since these emissions vary tremendously over the course of the year and between years. In addition, many fire emissions are part of the natural ecological process in many park forests. The cumulative impact analysis also considers emissions from Clark County, Nevada (Las Vegas) qualitatively to assess ambient air quality conditions in the western Grand Canyon (Lower Gorge alternatives). Although emissions from river-related activities do not drive pollutant concentrations in Clark County, the canyon is usually downwind of this area. Consequently, ambient conditions in Clark County have a profound influence on the "background" pollution levels into which Lower Gorge emissions occur. The analysis did not consider specific emissions from point sources, such as the Navajo Generating Plant near Page, Arizona, and the Mohave Power Project near Laughlin, Nevada.

Impact Thresholds

Impact thresholds for air quality depend on the type of pollutants produced, the background air quality, and the resources in the environment that may be affected by airborne pollutants (air quality related values). Air quality related values include "visibility and those scenic, cultural, biological, and recreation resources of an area that are affected by air quality" (43 FR 15016). Impacts are also affected by the spatial and temporal extent under which they occur.

Impact thresholds may be qualitative, such as photos of degraded visibility. They can also be quantitative, based on impacts on air quality related values or federal air quality standards, or

emissions based on emission factor models. The types of thresholds used in an analysis depend on what type of information is appropriate or available.

Impact Intensity

The Environmental Protection Agency has established standards that are regulated by states to protect human health and the environment. Consequently, two categories of potential airborne pollution impacts from recreational use of the Colorado River in Grand Canyon are analyzed for determining impact intensities. They include: (1) impacts on human health; and (2) impacts on air quality-related values in the canyon. Impact intensity thresholds for each impact category are discussed below.

Established threshold levels of total emissions that would characterize the significance criteria for mobile sources (such as helicopters and outboard motors) are not available. Therefore, estimates of total annual emissions under each alternative were compared to prevention of significant deterioration thresholds established in the Clean Air Act (40 CFR 51.166 (b)(1)(i)(b)) for stationary sources. Under prevention of significant deterioration, a major stationary source is:

- Any source in a fixed location that emits at least 250 tons per year of any pollutant regulated under the *Clean Air Act*; or
- Any source of 28 EPA-specified source categories that emit at least 100 tons per year of any regulated criteria pollutant.

The National Park Service has applied these prevention of significant deterioration stationary thresholds as significance criteria for non-road mobile sources for this analysis following the format used to evaluate personal watercraft in Glen Canyon National Recreation Area (NPS 2003d).

Human Health Effects from Airborne Pollutants. Based on the national standards and the methods described above, the following impact intensity thresholds for human health effects from airborne pollutants were defined. To assess a level of impact on human health from airborne pollutants, both the emissions of each pollutant related to recreational activity on the Colorado River, and the background air quality were evaluated and then considered according to the thresholds defined below.

	Activity Analyzed		Current Air Quality
Negligible:	Emission levels would be less than 50 tons per year for each pollutant.	**and**	The first highest three-year maximum for each pollutant is less than 60% of the national ambient air quality standards.
Minor:	Emission levels would be less than 100 tons per year for each pollutant.	**and**	The first highest three-year maximum for each pollutant is less than 80% of the national ambient air quality standards.

Moderate:	Emission levels would be greater than or equal to 100 tons per year for any pollutant.	**or**	The first highest three-year maximum for each pollutant is greater than 80% of the national ambient air quality standards.
Major:	Emission levels would be greater than or equal to 250 tons per year for any pollutant.	**and**	The first highest three-year maximum for each pollutant is greater than 80% of the national ambient air quality standards.

Air Quality Related Values. Impacts on environmental resources and values include visibility and biological resources (specifically ozone effects on plants) that may be affected by airborne pollutants emitted by recreational use. These pollutants include ozone, nitrogen oxides, total hydrocarbons, and particulate matter. Particulate matter and nitrogen oxide emissions are evaluated for visibility impairment. Volatile organic compounds and nitrogen oxides are precursors to the formation of ozone and are evaluated in lieu of ozone emissions, which is formed as a secondary pollutant.

To assess the impact of ozone on plants, the five-year ozone index value was calculated and is represented as SUM06. The NPS Air Resources Division, based on local monitoring site data, developed SUM06 values used in this analysis.

To assess a level of impact on air quality related values from airborne pollutants, both the emissions of each pollutant related to motorized activity and the background air quality were evaluated and then considered according to the intensity thresholds defined below.

	Activity Analyzed		**Current Air Quality**
Negligible:	Emission levels would be less than 50 tons per year for each pollutant. or No visibility impacts (exhaust plumes, exhaust odors, haze) are produced.	**and**	There are no perceptible visibility impacts (photos or anecdotal evidence) and There is no observed ozone injury to plants; and SUM06 ozone is less than 12 parts per million per hour (ppm/hr).

Minor:	Emission levels would be less than 100 tons per year for each pollutant. and Visibility and odor impacts are of very short duration and limited aerial extent.	**and**	SUM06 ozone is less than 15 ppm/hr.
Moderate:	Emission levels would be greater than 100 tons per year for any pollutant or Visibility impacts from cumulative emissions would be likely (based on past visual observations).	**or**	Ozone injury symptoms are identifiable on plants. and SUM06 ozone are less than 25 ppm/hr.
Major:	Emission levels would be equal to or greater than 250 tons per year for any pollutant. or Visibility impacts from cumulative emissions would be likely (based on modeling or monitoring).	**and**	Ozone injury symptoms are identifiable on plants. or SUM06 ozone is greater than 25 ppm/hr.

Context

Regional impacts from recreational activities have been considered along the entire river corridor in Grand Canyon, such as outboard motor exhaust from downstream travel. Localized impacts would occur in the immediate vicinity of sources producing air pollutants, such as campfires, or in a nearby area affected by a concentration of sources, such as attraction sites, launch or takeout areas, or exchange points.

Duration

Air quality is in a state of constant flux, responding to the production of air pollutants and the atmosphere's ability to disperse, dilute, or remove those pollutants. All alternatives produce some air pollution year-round, although the Lees Ferry alternatives would produce very little during those times when motors were not allowed (ranging from 3 to 12 months of the year). Local impacts, like an exhaust plume, generally dissipate quickly. Local haze and pollutant concentrations are very responsive to pollution production, and the pollutants are generally removed from the canyon over a period of hours (in summer)

to a few days (during winter inversion episodes). Other impacts, such as leaf damage by ozone, are cumulative over the growing season.

Timing

Most emissions are generated during the daytime hours where dispersion is generally greater. Time of day has a bearing on effects to air quality since winds in the canyon often blow upstream during the day and downstream at night. Seasonal conditions such as winter stagnation periods would tend to reduce the potential for dispersion resulting in potentially greater impacts. Winter cold fronts and high spring winds tend to disperse river-related pollutants rapidly, removing them from the canyon in a few days at most.

Mitigation of Effects

Previous mitigation efforts indicate that specific measures can be effective in reducing impacts to air quality, if adequate funding, staffing, monitoring, and implementation of the measures are maintained. Reasonable mitigations for impacts to air quality can be applied singly or in combination under the various alternatives. These mitigation measures include:

- spreading use to reduce peak concentrations of air pollutants
- use of cleaner-burning fuels and engines
- substitution of non- or less-polluting methods of power (i.e., use of oars instead of motors)
- not allowing engines to idle unnecessarily
- surveying sensitive plant species in the river corridor for leaf injury from ozone exposure
- continued NPS engagement with local, state, tribal, and federal air quality regulators to reduce air pollution transported into the park

In addition to direct mitigation measures, monitoring pollutant concentrations and effects of air pollution on park resources provide important information to assess "real world" conditions. Results might suggest strategies as appropriate (or inappropriate) for dealing with observed conditions.

Additional mitigation actions common to all Lees Ferry alternatives include the following:

- Measure CO levels at attraction and exchange sites to ensure levels measured on the South Rim are representative of the river corridor.

Additional mitigation actions common to all Lower Gorge alternatives include the following:

- Measure CO and ozone levels at attraction and exchange sites to establish better relationships between levels in the river corridor and those at the South Rim and in Clark County.
- Continue monitoring ozone and PM_{10} at Meadview to characterize ambient conditions in the Lower Gorge.

Assumptions

General assumptions used for analysis of effects from each alternative are discussed in the "Introduction" to Chapter 4. Assumptions that specifically relate to the alternatives in this document and their effect on air quality are presented below:

- Watercraft emissions are assumed to be constant, not changing in response to river flows. Although different flow regimes cause more or less use of outboard motors on river trips, data to define the relationships between flows, motor use, and trip lengths are not available.
- All outboard engines are assumed to be four-stroke engines.
- No engine degradation or non-exhaust total hydrocarbon/volatile organic compound emissions were considered in the emission estimates. Non-exhaust hydrocarbon emissions from watercraft are less than exhaust emissions but are not negligible. For watercraft, the principal sources of non-exhaust emissions are evaporative emissions from fuel tanks when the engine is not in use and refueling emissions. The quantities of these emissions are related to the number of pieces of equipment, number of trips, and watercraft fuel tank volume.
- Current engine types are assumed for all alternatives. Although other technologies have been discussed and even tested to varying degrees (i.e., electric motors, hydrogen fuel cells), these options are still unproved and their applications hypothetical during the analysis period.
- Emissions from up lake recreational boating from Lake Mead are not analyzed as part of the alternatives. With fluctuating lake levels, this use can vary dramatically, but this variation is independent from the plan alternatives. Adjacent waters of Lake Mead will be zoned "rural natural" or "semi-primitive" depending on the final decisions of this environmental impact statement, and the use of non-carbureted two-stroke engines will be prohibited on Lake Mead after 2012 (NPS 2002).
- Recreational use of the Colorado River will remain at the permitted levels (emissions will not change significantly) over the life of the plan.
- Helicopters used for passenger exchanges at Whitmore and Quartermaster land on take off solely on Hualapai Tribe lands. In the case of Quartermaster, the Hualapai Tribe has indicated that helicopter flights will occur in that area independent of the alternatives considered in this document and independent of whether any of the helicopter passengers are also river passengers.

IMPACT ANALYSIS — LEES FERRY ALTERNATIVES

Total emissions for each of these alternatives are summarized in Figure 4-2. To assess cumulative impacts, air pollution generated under Alternative 1 for the Lower Gorge was used in calculating existing total park emissions. The potential for impacts for the Lees Ferry alternatives is based on comparison among Lees Ferry alternatives.

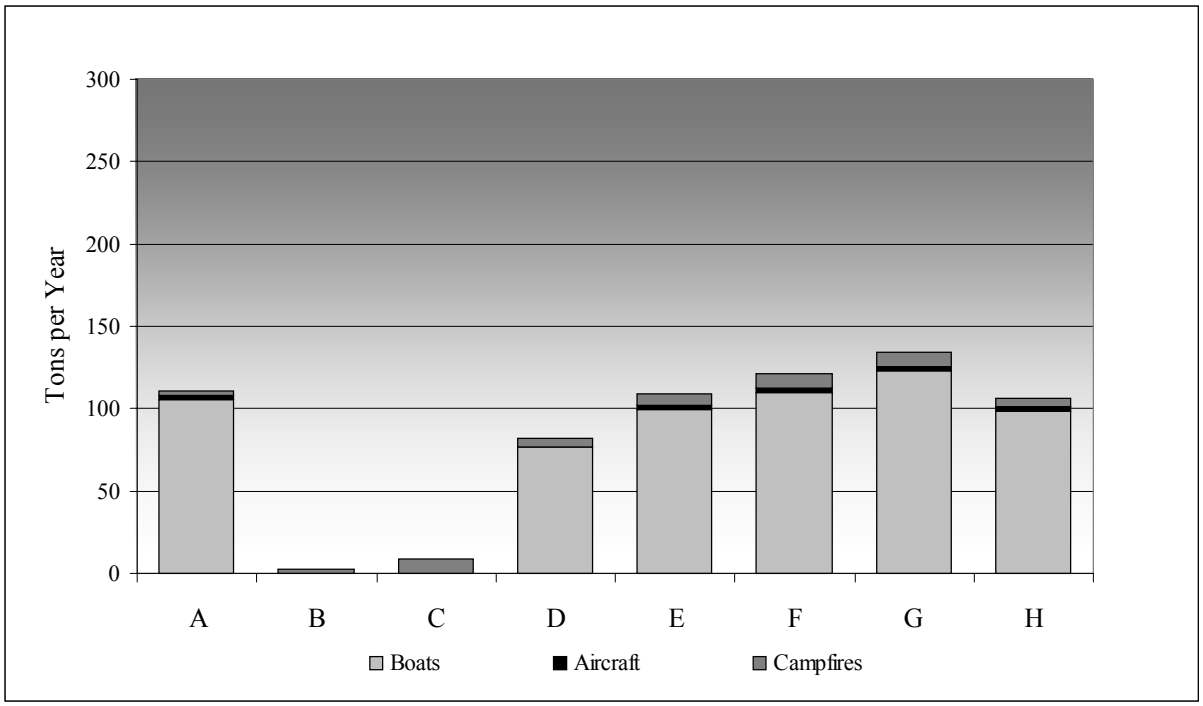
Alternative A (Existing Conditions)

Analysis. Under Alternative A management of recreational use would remain relatively similar to current levels. Use would remain concentrated during the summer months (May–October). A mix of non-motorized and motorized trips would continue to be allowed for nine months of the year, with a three-month no-motor season in the fall. Whitmore helicopter exchanges would continue. Estimated emissions under Alternative A, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-8.

TABLE 4-8: ALTERNATIVE A EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	858	4.36	98.68	2.12	0.01	0
Aircraft	1,660	0.21	1.39	0.98	0.03	0.13
Campfires		1.10	1.21	0.01	0.17	0.00
Total	**2,518**	**5.67**	**101.28**	**3.11**	**0.21**	**0.13**
Percentage of Park Total		2.90%	10.33%	2.92%	0.35%	4.06%

FIGURE 4-2: EMISSIONS DUE TO RECREATIONAL RIVER USE ABOVE DIAMOND CREEK



Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons per year, making impacts on human health negligible. Because CO emissions would be slightly greater than 100 tons per year, adverse impacts from current conditions would be moderate. Measured levels of CO in the park are very low (see Chapter 3), and continued implementation of this alternative should not cause them to exceed national standards. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, resulting in adverse, moderate impacts to human health. Ozone concentrations are

driven by NO_x and VOC emissions, but only negligible amounts of these pollutants would be generated annually under this alternative. Although these emissions contribute to ozone production, their contributions under this alternative would be negligible and would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO are much less than 50 tons a year, making their adverse impacts on air quality related values generally negligible. During the motor season, exhaust odors and plumes may occur under calm weather conditions at attraction sites, but dissipate rapidly, with negligible to minor adverse impacts. Localized, seasonal campfire plumes and odors also dissipate quickly, and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative A would have a negligible adverse contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions would result in a negligible contribution to these elevated exposures as they react to produce ozone.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative A make a generally small (less than 5%) contribution to air pollution produced in the Grand Canyon. The only exception is CO, where 10% of the park's emissions are associated with river use, supporting a moderate adverse impact from CO emissions, but a negligible adverse effect on human health because of the low ambient levels within the park. The most serious cumulative impacts result from high ozone exposure levels, to which this alternative makes a negligible, adverse impact. Cumulatively, the effects of Alternative A, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative A would make an adverse, negligible contribution to these cumulative effects.

Conclusion. Impacts of the VOCs, SO_2, PM_{10} and NO_x produced by continuing current recreational use of the Colorado River under Alternative A would have adverse, localized, negligible impacts on human health, and adverse, negligible to minor impacts on air quality related resources. Emissions of CO would continue to be moderate, but low ambient levels in the eastern park indicate adverse, local, negligible impacts to human health. Park vegetation would continue to experience adverse, major, regional impacts from ozone exposure, but emissions from Alternative A would result in a negligible, adverse, regional contribution to these exposures.

In summary, Alternative A would continue to have adverse, negligible, local effects on human health, and continue to make an adverse, negligible contribution to major regional impacts on air quality related resources. Alternative A would not result in the impairment of the air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts result from high ozone exposure levels, to which this alternative makes a negligible, adverse impact. Cumulatively, the effects of Alternative A, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative A would make an adverse, negligible contribution to these cumulative effects.

Alternative B

Analysis. Under Alternative B, recreational motor trips are prohibited, eliminating watercraft air pollutant emissions. Group sizes, trips and people at one time, daily launches, user-days, and probable total yearly passengers would be at their lowest (see Table 4-1), reducing campfire emissions. Trip lengths would be substantially reduced from current conditions, although user discretionary time would increase from current levels. There would be no passenger exchanges at Whitmore, eliminating aircraft emissions. Consequently, Alternative B would have the lowest air pollutant emissions of the Lees Ferry alternatives. Estimated emissions under Alternative B, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-9.

TABLE 4-9: ALTERNATIVE B EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	737	0	0	0	0	0
Aircraft	0	0	0	0	0	0
Campfires		1.33	1.47	0.02	0.20	0.00
Total	**737**	**1.33**	**1.47**	**0.02**	**0.20**	**0.00**
Percentage of Park Total		0.70%	0.17%	0.01%	0.34%	0.07%
Change from Alternative A (Current Conditions)						
Alternative B		-76%	-99%	-100%	-2%	-98%
Total Park		-2%	-10%	-3%	0%	-4%

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants would be much less than 50 tons per year, making their impacts on human health negligible. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, producing moderately adverse impacts to human health. Ozone concentrations would be driven by NO_x and VOC emissions, but only negligible amounts of these pollutants would be generated under

Alternative B annually. Although these emissions would contribute to ozone production, their contributions under this alternative would be negligible and would probably not change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants would be much less than 50 tons a year, making their impacts on air quality related values negligible. No exhaust odors or plumes would occur. Localized campfire plumes and odors dissipate quickly and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the minuscule amount of PM_{10} emitted under this alternative would result in a negligible adverse contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions under Alternative B would result in a negligible (essentially unmeasurable) contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative B would make a tiny (less than 1%) contribution to air pollution produced in Grand Canyon. Overall production of all pollutants in the canyon would be reduced from current levels, causing a negligible but beneficial impact on air quality. Annual production of CO would be reduced by 10% (about 100 tons), a moderate beneficial impact on air quality. The most serious cumulative impacts would result from continued high ozone exposure levels. Reductions in VOC and NO_x production under Alternative B would have a negligible beneficial impact on ozone exposures. Cumulatively, the effects of Alternative B, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative B would make a beneficial, negligible (essentially unmeasurable) contribution to these cumulative effects.

Conclusion. Reduced levels of VOCs, CO, SO_2, PM_{10} and NO_x that would be produced under Alternative B would have beneficial, long-term, negligible impacts on human health, and

beneficial, negligible impacts to air quality related resources. Emissions of CO would be negligible, and reductions from current conditions would have a moderate beneficial local impact to human health. Park vegetation would continue to experience major, negative, regional impacts from ozone exposure, but cumulative emissions reductions under Alternative B make a negligible (if measurable), beneficial, regional reduction in these exposures

In summary, Alternative B would have beneficial, negligible to moderate, long-term, effects on human health, and make a beneficial, negligible reduced contribution to adverse, major, regional effects on air quality related resources. Alternative B would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would result from continued high ozone exposure levels, to which this alternative would make a negligible, beneficial contribution compared to current operations. Cumulatively, the effects of Alternative B, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative B would make a beneficial, negligible (essentially unmeasurable) contribution to these cumulative effects.

Alternative C

Analysis. Under Alternative C visitor use would increase compared to Alternative B; however, air quality impacts would be largely the same. Motorized watercraft would not be permitted, and passenger exchanges at Whitmore would be by hiking, not aircraft. Increases in use during the shoulder and winter months would triple the number of campfires compared to current conditions, thus increasing campfire emissions. Estimated emissions under Alternative C, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-10.

TABLE 4-10: ALTERNATIVE C EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	1,098	0	0	0	0	0
Aircraft	0	0	0	0	0	0
Campfires		3.89	4.30	0.04	0.59	0.01
Total	**1,098**	**3.89**	**4.30**	**0.04**	**0.59**	**0.01**
Percentage of Park Total		2.01%	0.49%	0.04%	0.99%	0.22%
Change from Alternative A						
Alternative C		-31%	-96%	-99%	186%	-95%
Total Park		-1%	-10%	-3%	1%	-4%

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants would be much less than 50 tons per year, making their impacts on human health negligible. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, producing moderately adverse impacts to human health. Ozone concentrations would be driven by NO_x and VOC emissions, but only negligible amounts of these pollutants would be generated under Alternative C annually. Although these emissions contribute to ozone production, their contributions under this alternative would be negligible and would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants would be much less than 50 tons a year, making their impacts on air quality related values negligible. No exhaust odors and plumes would occur. Localized seasonal campfire plumes and odors dissipate quickly and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the amount of PM_{10} emitted under Alternative C would result in a negligible, seasonal, adverse contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions under Alternative C would result in a negligible (essentially unmeasurable) contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative C would result in a small (less than 2%) contribution to air pollution produced in Grand Canyon. Overall production of all pollutants except PM_{10} in the canyon would be reduced from current levels, causing a negligible but beneficial impact on air quality. Although PM_{10} emissions from river-related activities would be substantially higher than current emissions, their contribution to overall park emissions would only be 1%, causing a negligible adverse impact on visibility. Annual parkwide production of CO would be reduced by 10% (about 95 tons), a minor beneficial impact on air quality. The most serious cumulative impacts would continue to result from high ozone exposure levels. Reductions in VOC and NO_x production under Alternative C would have a negligible beneficial impact on ozone exposure. Cumulatively, the effects of Alternative C, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative C would make a beneficial, negligible (essentially unmeasurable) contribution to these cumulative effects.

Conclusion. Reduced levels of VOCs, CO, SO_2, and NO_x produced under Alternative C would have beneficial, local, negligible impacts on human health, and beneficial, local, negligible impacts on air quality related resources. Increased PM_{10} emissions would have a negligible, adverse, local, seasonal impact on visibility. Emissions of CO would be negligible, and

reductions from current conditions would have a minor, beneficial, local impact to human health. Park vegetation would continue to experience major, negative, regional impacts from ozone exposure, but cumulative emissions reductions under Alternative C make a negligible (if measurable), beneficial, regional reduction in these exposures.

In summary, Alternative C would have beneficial, negligible to minor, local effects on human health, and make a beneficial, negligible reduced contribution to adverse, negligible to major, local, seasonal effects on air quality related resources. Alternative C would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would continue to result from high ozone exposure levels, to which this alternative would make a negligible, beneficial contribution compared to current operations. Cumulatively, the effects of Alternative C, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative C would make a beneficial, negligible (essentially unmeasurable) contribution to these cumulative effects.

Alternative D

Analysis. Under Alternative D moderate user-day levels are projected, with a mid-range of trips at one time and low levels of people at one time. There would be a mix of motorized and non-motorized trips, with four motor-free months (March-April, September-October). Passenger exchanges at Whitmore would by hiking, eliminating aircraft emissions. Increased use in the shoulder and winter seasons would double the number of campfires compared to current conditions. Estimated emissions under Alternative D, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-11.

TABLE 4-11: ALTERNATIVE D EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	1,073	3.2	72.32	1.55	0.01	0
Aircraft	0	0	0	0	0	0
Campfires		2.34	2.59	0.03	0.35	0
Total	**1,073**	**5.54**	**74.91**	**1.58**	**0.36**	**0**
Percentage of Park Total		2.84%	7.85%	1.50%	0.61%	0.13%
Change from No-Action Alternative						
Alternative		-2%	-26%	-49%	77%	-97%
Total Park		0%	-3%	-1%	0%	-4%

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons per year, making their impacts on human health negligible. Because CO emissions would be between 50 and 100 tons per year, adverse impacts under Alternative D would be minor. Measured levels of CO in the eastern park are very low (see Chapter 3), and implementation of this alternative should not cause them to exceed national standards. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, producing moderate adverse impacts to human health. Ozone concentrations would be driven by NO_x and VOC emissions, but only negligible amounts of these pollutants would be generated under this alternative annually. Although these emissions contribute to ozone production, their

contributions under this alternative would be negligible and would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons a year, making the adverse impacts on air quality related values negligible. During the motorized use season exhaust odors and plumes could occur under calm weather conditions at attraction sites, but tend to dissipate rapidly, with negligible to minor, adverse, local impacts. Localized campfire plumes and odors also dissipate quickly, and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative D would result in a negligible contribution to visibility problems. Ozone exposure statistics for the park would continue to be well above 25 ppm/hr, which indicates a potentially major adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions make a negligible contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative D would result in a generally small (less than 3%) contribution to air pollution produced in the Grand Canyon. The only exception would be CO, where nearly 8% of the park's emissions would be associated with river use. Implementation of Alternative D would reduce overall park emissions of CO, NO_x, and SO_2. These decreases would produce a negligible, but beneficial, cumulative impact. Overall park emissions of VOCs and PM_{10} would remain essentially unchanged from current conditions. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would result in a negligible, beneficial impact by its small reduction in NO_x emissions. Cumulatively, the effects of Alternative D, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative D would make a beneficial, negligible contribution to these cumulative effects.

Conclusion. Reduced overall park emissions of CO, SO_2, and NO_x under Alternative D would have beneficial, local, negligible impacts on human health, and beneficial, negligible impacts on air quality related resources. Parkwide emissions of PM_{10} and VOCs would remain essentially unchanged from current conditions. Park vegetation would continue to experience major, adverse, regional impacts from ozone exposure, overall NO_x emission reductions under Alternative D would produce a negligible reduction to these regional exposures.

In summary, Alternative D would have beneficial, negligible, local effects on human health and would have generally beneficial, negligible effects by reducing contributions to adverse, major, regional effects on air quality related resources. Alternative D would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would make a negligible, beneficial impact through its small reduction in NO_x emissions compared to current operations. Cumulatively, the effects of Alternative D, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative D would make a beneficial, negligible contribution to these cumulative effects.

Alternative E

Analysis. Under Alternative E longer trip lengths result in lower maximum numbers of trips and people at one time, with mid-range numbers of user-days and user discretionary time. River trips would use a mix of motorized and non-motorized watercraft for half the year, with motors prohibited from October through March. Although passenger exchanges at Whitmore would be allowed year-round, helicopter exchanges would be prohibited in the non-motor season (October through March). Increased river recreation in the shoulder and winter months relative to current patterns would result in a tripling of campfires from current levels. Estimated emissions under Alternative E, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-12.

TABLE 4-12: ALTERNATIVE E EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	1,196	4.12	93.26	2.00	0.01	0
Aircraft	1,660	0.21	1.39	0.98	0.03	0.13
Campfires		3.13	3.45	0.04	0.47	0.01
Total	**2,856**	**7.46**	**98.10**	**3.02**	**0.51**	**0.14**
Percentage of Park Total		3.78%	10.04%	2.83%	0.86%	4.16%
Change from Alternative 1						
Alternative		32%	-3%	-3%	149%	3%
Total Park		1%	0%	0%	1%	0%

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons per year, making adverse impacts on human health negligible. Because CO emissions would be between 50 and 100 tons per year, adverse impacts under Alternative E would be minor. Measured levels of CO in the park ARE very low (see Chapter 3), and implementation of this alternative should not cause them to exceed national standards. Current

ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, producing moderate adverse impacts to human health. Ozone concentrations are driven by NO_x and VOC emissions, but only negligible amounts of these pollutants would be generated annually under this alternative. Although these emissions would contribute to ozone production, their negligible emissions under this alternative would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons a year, making adverse impacts on air quality related values negligible. During the motor season, exhaust odors and plumes could occur under calm weather conditions at attraction sites, but should dissipate rapidly since use would be during non-winter months, resulting in adverse, local, negligible to minor impacts. Localized, seasonal campfire plumes and odors also dissipate quickly and would generally not be considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative E would have a negligible, adverse, generally local and in-season contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, adverse, regional impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions make a negligible contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative E would result in a generally small (less than 5%) contribution to air pollution produced in the Grand Canyon. The only exception is CO, where about 10% of the park's emissions would be associated with river use. The larger percentage increase in VOC and PM_{10} emissions above current conditions would still drive only a 1% change in total park emissions for those pollutants, so adverse impacts from this change would probably not be measurable. Implementation of Alternative E would result in virtually no change in overall park emissions (0%–1%). The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would contribute a negligible amount due to a small increase in VOC emissions. Cumulatively, the effects of Alternative

E, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative E would make an adverse, negligible contribution to these cumulative effects.

Conclusion. Overall park emissions under Alternative E would remain virtually the same as current conditions. Recreational use would continue to have adverse, local, negligible impacts on human health, and adverse, regional, negligible to minor impacts on air quality related resources. Emissions of CO would be minor, but low ambient levels in the park indicate negligible, adverse, regional impacts to human health. Park vegetation would continue to experience adverse, regional, major impacts from ozone exposure, but emissions under Alternative E would result in a negligible contribution to these exposures.

In summary, Alternative E would have adverse, local to regional, negligible effects on human health, and it would result in adverse, negligible, increased contributions to major regional effects on air quality related resources. Alternative E would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would contribute a negligible amount due to a small increase in VOC emissions compared to current operations. Cumulatively, the effects of Alternative E, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative E would make an adverse, negligible contribution to these cumulative effects.

Alternative F

Analysis. Under Alternative F use patterns would generally result in a mid-range level of user-days, trips and people at one time, and user discretionary time. A mix of motorized and non-motorized use would occur for the first half of the year, and motorized watercraft and Whitmore exchange aircraft would be prohibited from July through September. Increased non-summer recreational use would triple the number of expected campfires from current levels. Estimated emissions under Alternative F, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-13.

TABLE 4-13: ALTERNATIVE F EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	1,253	4.55	103.08	2.21	0.01	0
Aircraft	1,660	0.21	1.39	0.98	0.03	0.13
Campfires		3.75	4.14	0.04	0.57	0.01
Total	**2,913**	**8.51**	**108.61**	**3.23**	**0.61**	**0.14**
Percentage of Park Total		4.30%	10.99%	3.03%	1.02%	4.19%
Change from Alternative 1						
Alternative		50%	7%	4%	195%	4%
Total Park		1%	1%	0%	1%	0%

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons per year, resulting in adverse, negligible impacts on human health.

Because CO emissions would be over 100 tons per year, adverse impacts during the motor season under Alternative F would be moderate. Measured levels of CO in the park are very low (see Chapter 3), and implementation of this alternative should not cause them to exceed national standards. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, resulting in moderate adverse impacts to human health. Ozone concentrations are driven by NO_x and VOC emissions, but only negligible amounts of these pollutants would be generated annually under this alternative. Although these emissions would contribute to ozone production, their negligible emissions under this alternative would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons a year, resulting in adverse, negligible impacts on air quality related values. Exhaust odors and plumes could occur under calm weather conditions at attraction sites during the motor season, but would dissipate rapidly, with adverse, local, negligible to minor impacts. Localized campfire plumes and odors would also dissipate quickly, and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative F would result in a negligible, seasonal, adverse contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, adverse, regional impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low increase in combined NO_x and VOC emissions would have a negligible adverse contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative F would have a generally small (less than 5%) contribution to air pollution produced in Grand Canyon. The only exception would be CO, where 11% of the park's emissions would be associated with river use. The large percentage increase in VOC and PM_{10} emissions from current conditions would cause only a 1% change in total park emissions for those pollutants, so adverse impacts from this change would probably not be measurable. Alternative F would make virtually no change in overall park emissions (0%–1%). The most serious cumulative impacts would result from high

ozone exposure levels, to which this alternative would result in a negligible, adverse, regional impact by its small increase in VOC emissions. Cumulatively, the effects of Alternative F, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative F would make an adverse, negligible contribution to these cumulative effects.

Conclusion. Overall park emissions under Alternative F would remain virtually the same as current conditions. Recreational use would continue to have adverse, regional, and negligible impacts on human health, and adverse, regional, and negligible to minor impacts on air quality related resources, as well as adverse, local, short-term, negligible impacts to visibility. Emissions of CO would be moderate, but low ambient levels in the park indicate adverse, regional, negligible impacts to human health. Park vegetation would continue to experience major, adverse, regional impacts from ozone exposure; emissions under Alternative F would result in a negligible contribution to these exposures.

In summary, Alternative F would have adverse, regional, negligible impacts on human health and result in adverse, negligible contributions to adverse, local to regional, major impacts on air quality related resources. Alternative F would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would make an adverse, regional, negligible impact through its small increase in VOC emissions compared to current operations. Cumulatively, the effects of Alternative F, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative F would make an adverse, negligible contribution to these cumulative effects.

Alternative G

Analysis. Alternative G proposes the largest group sizes (except for Alternative A) and largest number of noncommercial user-days of any of the alternatives, with the lowest maximum number of trips at one time but the second highest maximum number of people at one time. User discretionary time would be the second lowest due in large part to the shortest trip lengths. It would have a mix of motorized and non-motorized trips, with a three-month non-motorized season (September-December), during which time there would be no Whitmore helicopter exchanges (although hiking exchanges would be allowed). Use would be spread throughout the year, resulting in more campfires than the other alternatives. Overall, Alternative G would have the highest projected emissions of the Lees Ferry alternatives. Estimated emissions under Alternative G, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-14.

Human Health Impacts From Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons per year, resulting in negligible impacts on human health. Because CO emissions would be greater than 100 tons per year, adverse impacts under Alternative G would be adverse, regional, and moderate. Measured levels of CO in the park are very low (see Chapter 3), and this alternative should not cause them to exceed national standards. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard,

TABLE 4-14: ALTERNATIVE G EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	1,406	5.09	115.35	2.47	0.02	0
Aircraft	1,660	0.21	1.39	0.98	0.03	0.13
Campfires		3.91	4.32	0.04	0.59	0.01
Total	**3,066**	**9.21**	**121.06**	**3.49**	**0.64**	**0.14**
Percentage of Park Total		4.63%	12.10%	3.26%	1.07%	4.20%
Change from Alternative 1						
Alternative		63%	20%	12%	211%	4%
Total Park		2%	2%	0%	1%	0%

resulting in adverse, moderate impacts to human health. Ozone concentrations are driven by NO_x and VOC emissions, but negligible amounts of these pollutants would be generated under this alternative. These emissions would adversely contribute to ozone production, but their contributions would be negligible and would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons a year, resulting in adverse, negligible impacts on air quality related values. Exhaust odors and plumes during the motorized use season might occur under calm weather conditions at attraction sites, but would dissipate rapidly, with adverse, local, short-term, negligible to minor impacts. Localized campfire plumes and odors would also dissipate quickly and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative G would result in a negligible, local, short-term contribution to visibility problems, even though there would be a substantial percentage increase from current conditions. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially adverse, regional, major impacts on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions would have an adverse, regional, negligible contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative G would result in a generally small (less than 5%) contribution to air pollution produced in the Grand Canyon. The only exception would be CO, where 12% of the park's emissions would be associated with river use, supporting an adverse, regional, moderate impact from CO emissions, but a negligible, adverse, regional effect on human health because of the low ambient levels within the park. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would make an adverse, regional, negligible impact because of increased VOC and NO_x emissions. Cumulatively, the effects of Alternative G, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative G would make an adverse, negligible to minor contribution to these cumulative effects.

Conclusion. Impacts of the VOCs, SO_2, PM_{10} and NO_x produced by continuing current recreational use of the Colorado River under Alternative G would have adverse, regional, negligible impacts on human health, and adverse, regional, negligible to minor impacts on air quality related resources, including minor, local, short-term impacts to visibility. Emissions of CO would increase slightly but would remain at moderate levels. Low ambient CO levels in the park indicate adverse, regional, negligible impacts to human health. Park vegetation would continue to experience adverse, major regional impacts from ozone exposure, but emissions from Alternative G would result in a negligible contribution to these exposures.

In summary, Alternative G would have adverse, negligible, regional impacts on human health, with adverse, negligible to minor contributions to major, local to regional, short- and long term impacts on air quality related resources. Alternative G would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would make an adverse, regional, negligible impact by its small increase in VOC emissions compared to current operations. Cumulatively, the effects of Alternative G, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative G would make an adverse, negligible to minor contribution to these cumulative effects.

Alternative H (NPS Preferred Alternative)

Analysis. Under Alternative H a large number of passengers would pass through Grand Canyon. Maximum numbers of people at one time would be relatively high, but maximum numbers of trips at one time would be moderate, as well as total user discretionary time. A mix of motorized and non-motorized use would for six months, with a six month (September-February) no-motor season. Helicopter exchanges at Whitmore would occur during a four month period (May-August). Seasonal use would be distributed such that there would be about twice as many campfires as are expected under current conditions. Estimated emissions under Alternative H, and their relationship to total emissions in Grand Canyon National Park, are presented in Table 4-15.

TABLE 4-15: ALTERNATIVE H EMISSIONS
tons / year

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	1,100	4.09	92.63	1.98	0.01	0
Aircraft	1,580	0.21	1.39	0.98	0.03	0.13
Campfires		2.36	2.60	0.03	0.36	0.00
Total	**2,680**	**6.66**	**96.62**	**2.99**	**0.40**	**0.13**
Percentage of Park Total		3.39%	9.90%	2.80%	0.67%	4.12%
Change from Alternative 1						
Alternative		17%	-5%	-4%	92%	2%
Total Park		1%	0%	0%	0%	0%

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons per year, resulting in adverse, negligible impacts on human health. Because CO emissions would be between 50 and 100 tons per year, adverse impacts under Alternative H would be minor and seasonal. Measured levels of CO in the park are very low (see Chapter 3), and implementation of this alternative should not cause them to exceed national standards. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard, resulting in adverse, moderate impacts to human health. Ozone concentrations are driven by NO_x and VOC emissions, but only negligible amounts of these pollutants are generated under this alternative annually. Although these emissions contribute to ozone production, negligible emissions under this alternative would not be expected to change the park's attainment status for ozone.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be much less than 50 tons a year, resulting in adverse, negligible impacts on air quality related values. Exhaust odors and plumes could occur under calm weather conditions at attraction sites during the motorized use season, but would dissipate rapidly, with adverse, short-term, seasonal, negligible to minor impacts. Localized campfire plumes and odors also dissipate quickly, and are generally not considered objectionable. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative H would result in a negligible, largely local and short-term contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, adverse, regional, long term impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see "Cumulative Effects"). The low combined NO_x and VOC emissions would result in a negligible contribution to these elevated exposures.

Mitigation of Effects. See air quality mitigation actions common to all alternatives and common to all Lees Ferry alternatives beginning on page 302.

Cumulative Effects. Specific effects from past, present, and reasonably foreseeable actions are discussed earlier in this chapter. Air quality in the Grand Canyon area is generally good, but pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (U.S. EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and

control and are the subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions from recreational use of the Colorado River under Alternative H would result in a generally small (less than 5%) contribution to the air pollution produced in the Grand Canyon. The only exception would be CO, where nearly 10% of the park's emissions are associated with river use. The larger percentage increases in VOC and PM_{10} emissions from current conditions would change total park emissions for those pollutants by 1% or less, so adverse impacts from this change would not be measurable. Implementation of Alternative H makes virtually no change in overall park emissions. The most serious cumulative impacts result from high ozone exposure levels, to which this alternative would result in a negligible, adverse impact by its small increase in combined VOC and NO_x emissions compared to current operations. Cumulatively, the effects of Alternative H, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative H would make an adverse, negligible to minor contribution to these cumulative effects.

Conclusion. Since overall park emissions under Alternative H remain virtually the same as current conditions, little or no change from current conditions would be expected. Recreational use would continue to have negligible, adverse, regional impacts on human health, and negligible to minor, adverse, regional impacts on air quality related resources, including minor, short-term, local impacts to visibility. Emissions of CO would be minor, but low ambient levels in the park indicate negligible, adverse, regional impacts to human health. Park vegetation would continue to experience major, adverse, regional impacts from ozone exposure, but emissions from Alternative H would result in a negligible contribution to these exposures.

In summary, Alternative H would have adverse, negligible, regional impacts on human health, and make adverse, negligible to minor contributions to major, adverse, local to regional, short- and long-term impacts on air quality related resources. Alternative H would not result in the impairment of air quality and related resources in Grand Canyon National Park. The most serious cumulative impacts would result from high ozone exposure levels, to which this alternative would make an adverse, negligible impact through its small increase in combined VOC and NO_x emissions compared to current operations. Cumulatively, the effects of Alternative H, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative H would make an adverse, negligible to minor contribution to these cumulative effects.

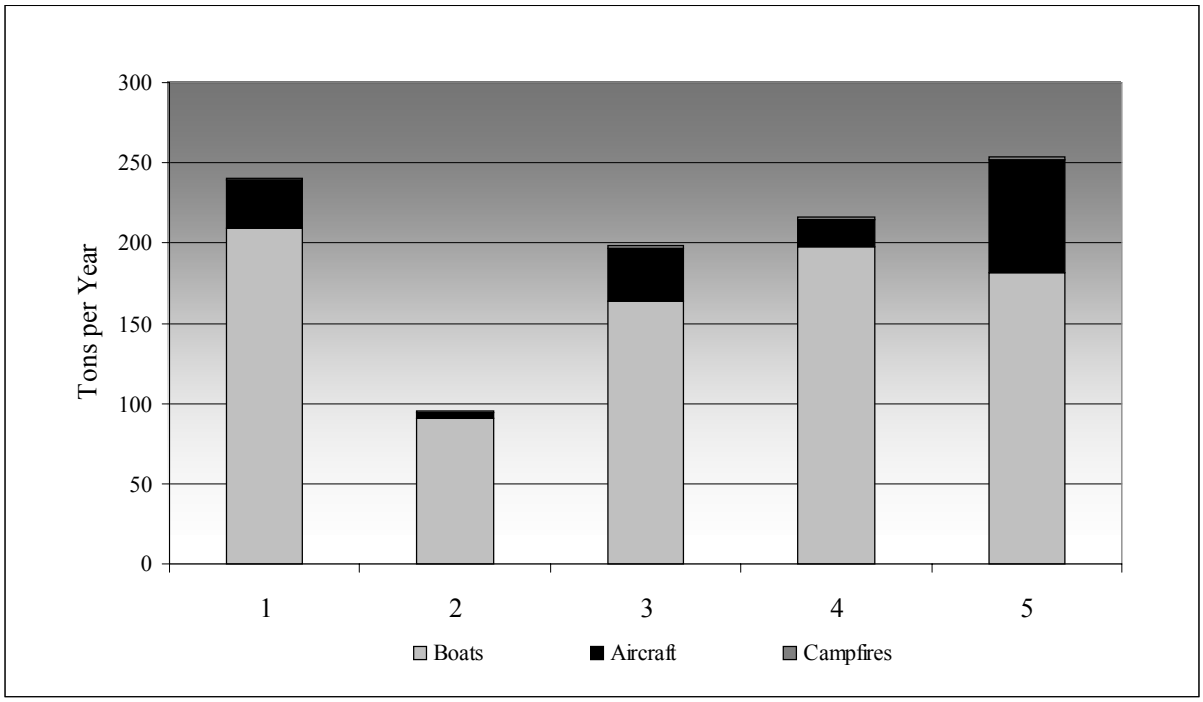
IMPACT ANALYSIS — LOWER GORGE ALTERNATIVES

The potential impacts of the Lower Gorge alternatives are based on a comparison among Lower Gorge alternatives. An overview of total emissions from the five alternatives is shown in Figure 4-3. For the analysis of cumulative impacts, air pollution generated under current conditions as

described in Lees Ferry Alternative A was used in calculating total park emissions. Ambient air quality in Clark County, Nevada (Las Vegas), is also considered qualitatively in evaluating conditions in the Lower Gorge because of its geographic proximity.

Depending on the surface elevation of Lake Mead, there can be varying amounts of up-lake recreational boating. The amount of private up-lake boating is not regulated under these alternatives (although personal watercraft or jet skis are prohibited). This use varies in response to lake levels, independent of the management alternatives, and statistics on these varying use levels is not available. Consequently, private upriver watercraft emissions are not included in this analysis.

FIGURE 4-3: EMISSIONS DUE TO RECREATIONAL RIVER USE BELOW DIAMOND CREEK



Alternative 1 (Current Conditions)

Analysis. Alternative 1 represents the current diverse mix of recreational activities on the Colorado River below Diamond Creek and Lake Mead within the Grand Canyon. Uses include private and commercial trips, pontoon boat tours, and upriver takeouts. Most watercraft use engines, either four-stroke outboard or diesels (on the takeout jetboats). Helicopters are used to shuttle pontoon tour and some commercial passengers to and from the south rim near Quartermaster. Overall emissions of air pollutants under Alternative 1 are summarized in Table 4-16.

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO are less than 50 tons per year, making their impacts on human health negligible. CO emissions are moderate, less than 250 tons per year. Levels of CO measured in the eastern section of the park

TABLE 4-16: ALTERNATIVE 1 EMISSIONS TONS / YEAR

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	19,967	8.45	183.24	17.17	0.41	0.00
Aircraft	33,215	3.41	23.09	3.27	0.00	0.40
Campfires		0.57	0.63	0.01	0.09	0.00
Total	**53,182**	**12.43**	**206.95**	**20.45**	**0.49**	**0.40**
Percentage of Park Total		6.36%	21.10%	19.17%	0.83%	12.20%

are very low, while those measured in the Las Vegas metropolitan area are substantially higher (see Chapter 3). Although Clark County is designated nonattainment for CO (meaning it does not meet the national standards), all monitoring stations in the county reported levels less than 80% of the national ambient air quality standards for CO from 2001-2003 (U.S. EPA 2004). Consequently, continued implementation of this alternative should not cause CO in the Lower Gorge to exceed national standards, and impacts to human health would remain adverse, moderate and regional. Combined emissions of VOCs and NO_x are less than 50 tons per year, and thus at the negligible impact level for ozone-producing emissions. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard. Clark County was designated nonattainment for ozone under the 8-hour standard, violating the standard in 2002 and 2003, but has requested a deferral of that designation until September 2004. Although River-related emissions contribute to ozone production, their contributions under this alternative are negligible, and would not be expected to change the park's attainment status for ozone. Impacts to human health from ozone would remain regional, adverse and moderate.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons a year, making their adverse impacts on air quality related values generally negligible. Exhaust odors and plumes may occur under calm weather conditions at attraction sites, particularly near Quartermaster. Fuel odors associated with helicopter traffic are sometimes noticeable over a half-mile radius. Localized campfire plumes and odors dissipate quickly, and are generally not considered objectionable. These impacts are minor, local and adverse. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative 1 makes a negligible, local, adverse contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, regional, adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see Chapter 3). The low combined NO_x and VOC emissions make a negligible contribution to these elevated exposures.

Mitigation of Effects. Air quality mitigation actions would be common to all alternatives, including the Lees Ferry alternatives, and are listed beginning on page 302.

Cumulative Effects. As described in Chapter 3 and for the Lees Ferry alternatives, road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions of PM_{10} from recreational use of the Colorado River under Alternative 1 would result in a minimal (below 1%) contribution to air pollution produced in Grand Canyon. All other pollutants would make more significant contributions. Emissions of CO would be about 21% of

total park emissions for this pollutant. The Lower Gorge meets national standards for air quality (attainment or unclassified), but nearby Clark County is classified as a nonattainment area for CO, PM_{10}, and perhaps ozone. River-related emissions do not drive these elevated concentrations (Grand Canyon is almost always downwind of Clark County). However, transport of this polluted air into the Lower Gorge exacerbates the adverse effects of river-related emissions on human health, visibility, and ozone exposure. The most serious cumulative human health concerns result from CO and ozone levels, which under Alternative 1 would remain adverse, regional, and moderate. Cumulatively, the effects of Alternative 1, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 1 would make an adverse, negligible contribution to these cumulative effects.

Conclusion. Impacts of the VOCs, SO_2, PM_{10} and NO_x produced by continuing current recreational use of the Colorado River under Alternative 1 would have negligible, adverse, regional impacts on human health, and negligible to minor, regional, adverse impacts on air quality related resources. Emissions of CO would continue to be moderate, and ambient levels in the region indicate moderate, regional, adverse impacts to human health. Park vegetation would continue to experience major, adverse, regional impacts from ozone exposure, and visibility would continue to be moderately degraded, but emissions from Alternative 1 make a negligible to minor, local, short-term contribution to these impacts.

In summary, Alternative 1 would have adverse, negligible to moderate, regional effects on human health (CO and ozone), and make adverse, negligible to minor contributions to major, local to regional, short-term, effects on air quality related resources (visibility, ozone exposure, and odor). Alternative 1 would not result in the impairment of air quality and related resources in Grand Canyon National Park. Cumulatively, the effects of Alternative 1, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 1 would make an adverse, negligible contribution to these cumulative effects.

Alternative 2

Analysis. Under Alternative 2 recreational use of the Lower Gorge is reduced from current levels. Raft trips continue, but use levels are capped, generally near current levels. Only helicopter shuttles associated with HRR exchanges would continue. Pontoon boat tours and their associated helicopter shuttles would be eliminated. Jetboats would be used for commercial takeouts, but at reduced levels compared to Alternative 1. Overall emissions of air pollutants under Alternative 2 are lower than the other Diamond Creek alternatives, and are summarized in Table 4-17.

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO are much less than 50 tons per year, making their impacts on human health negligible. CO emissions are minor (less than 100 tons per year). Levels of CO measured in the eastern section of the park are very low, while those measured in the Las Vegas metropolitan area are substantially higher (see Chapter 3). Implementation of Alternative 2 should not cause CO in the Lower Gorge to exceed national standards, and its impacts to human health would remain adverse, regional, and

TABLE 4-17: ALTERNATIVE 2 EMISSIONS
TONS / YEAR

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	3,985	3.70	81.64	5.06	0.10	0.00
Aircraft	4,265	0.44	2.97	0.42	0.00	0.05
Campfires		0.34	0.38	0.00	0.05	0.00
Total	**8,250**	4.48	84.98	5.49	0.15	0.05
Percentage of Park Total		2.39%	9.90%	5.98%	0.26%	1.77%
Change from Alternative 1						
Alternative			64%	59%	73%	-87%
Total Park			4%	12%	14%	-11%

moderate. Combined emissions of VOCs and NO_x are less than 50 tons per year, and thus at the negligible impact level for ozone-producing emissions. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard. Clark County was designated nonattainment for ozone under the 8-hour standard, but has requested a deferral of that designation until September 2004. Although River-related emissions contribute to ozone production, their contributions under this alternative are negligible, and would not be expected to change the park's attainment status for ozone. Impacts to human health from ozone would remain adverse, regional and moderate.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO are less than 50 tons a year, making their adverse impacts on air quality related values generally negligible. Exhaust odors and plumes may occur under calm weather conditions at attraction sites. Fuel odors associated with helicopter traffic may be noticeable near Quartermaster, but greatly reduced compared to Alternative 1. Localized campfire plumes and odors dissipate quickly, and are generally not considered objectionable. These impacts are minor, local and adverse. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative 2 makes a negligible, adverse, regional contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, regional, adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see Chapter 3). The low combined NO_x and VOC emissions make a negligible contribution to these elevated exposures.

Mitigation of Effects. Air quality mitigation actions would be common to all alternatives, including the Lees Ferry alternatives, and are listed beginning on page 302.

Cumulative Effects. As described in Chapter 3 and for the Lees Ferry alternatives, road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions of VOCs, NO_x, SO_2 and PM_{10} from recreational use of the Colorado River under Alternative 2 would result in a small (less than 4%) contribution to total air pollution produced in Grand Canyon; CO makes a larger (10%) contribution. Compared with current conditions under Alternative 1, Alternative 2 would result in substantial reductions (59%–87%), although reductions in the total overall emissions of VOCs, NO_x, SO_2, and PM_{10} in the canyon would be much less. However, the 59% reduction in CO emissions (122 tons) would reduce overall park CO emissions by 12%, a beneficial, regional, moderate impact. The Lower Gorge meets national

standards for air quality (attainment or unclassified), but nearby Clark County is classified nonattainment for CO, PM_{10}, and perhaps ozone. River-related emissions do not drive these elevated concentrations, but transport of this polluted air into the Lower Gorge exacerbates the adverse effects of river-related emissions on human health, visibility, and ozone exposure. Even though local pollutant concentrations would benefit from reduced emissions under Alternative 2, cumulative impacts from air pollution will remain. The most serious cumulative human health concerns result from CO and ozone levels, which under Alternative 2 would remain moderate, regional, and adverse. Cumulatively, the effects of Alternative 2, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 2 would make a beneficial, negligible contribution to these cumulative effects.

Conclusion. Impacts of the VOCs, SO_2, PM_{10} and NO_x produced by recreational use of the Colorado River under Alternative 2 would have negligible, regional adverse impacts on human health, and negligible to minor, regional, adverse impacts on air quality related resources. With beneficial, moderate reductions, emissions of CO would drop to minor levels, but ambient levels in the region indicate adverse, regional, moderate impacts to human health. Park vegetation would continue to experience adverse, regional, major impacts from ozone exposure, and visibility would continue to be moderately degraded, but reduced emissions under Alternative 2 compared with current conditions would create a negligible, regional and local, beneficial reduction in these impacts.

In summary, Alternative 2 would make beneficial, moderate reductions to adverse, moderate, regional impacts on human health from CO, and beneficial, negligible reductions in contributions to adverse, major, regional effects on air quality related resources (plant ozone exposure and visibility). Alternative 2 would not result in the impairment of air quality and related resources in Grand Canyon National Park. Cumulatively, the effects of Alternative 2, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 2 would make a beneficial, negligible contribution to these cumulative effects.

Alternative 3

Analysis. Alternative 3 allows the same mix of recreational opportunities as current conditions, but at different levels. HRR day use would decline slightly, but overnight trips increase. Pontoon tours in the Quartermaster area increase, as do commercial takeouts. Helicopter shuttles for pontoon trips and passenger takeouts continue. Overall emissions of air pollutants under Alternative 3 are summarized in Table 4-18.

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons per year, making their impacts on human health negligible. CO emissions would be moderate (between 100 and 250 tons per year). Levels of CO measured in the eastern section of the park are very low, while those measured in the Las Vegas metropolitan area are substantially higher (see Chapter 3). Although Clark County is designated nonattainment for CO (meaning it does not meet the national standards), all monitoring stations in the county reported levels less than 80% of the national ambient air quality standards for CO from 2001 to 2003

TABLE 4-18: ALTERNATIVE 3 EMISSIONS TONS / YEAR

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	10,358	6.44	133.87	22.61	0.59	0.00
Aircraft	36,992	3.80	25.72	3.64	0.00	0.44
Campfires		0.46	0.50	0.01	0.07	0.00
Total	**47,350**	**10.70**	**160.09**	**26.25**	**0.66**	**0.44**
Percentage of Park Total		5.53%	17.14%	23.34%	1.12%	13.39%
Change from Alternative 1						
Alternative		-14%	-23%	28%	34%	11%
Total Park		-1%	-5%	5%	0%	1%

(U.S. EPA 2004). Implementation of Alternative 3 should reduce CO emissions in the Lower Gorge 23% and would not cause CO to exceed national standards, but impacts to human health would remain adverse, regional and moderate. Combined emissions of VOCs and NO_x would be less than 50 tons per year, and thus at the negligible impact level for ozone-producing emissions. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard. Clark County was designated nonattainment for ozone under the 8-hour standard, but has requested a deferral of that designation until September 2004. River-related emissions contribute to ozone production, but their combined contributions under this alternative would be negligible and would not be expected to change the park's attainment status for ozone. Impacts to human health from ozone would remain adverse, regional, and moderate.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons a year, making their adverse impacts on air quality related values generally negligible. Exhaust odors and plumes may occur under calm weather conditions at attraction sites, particularly near Quartermaster. Fuel odors associated with helicopter traffic may be noticeable over a half-mile radius. Localized campfire plumes and odors dissipate quickly and are generally not considered objectionable. These impacts are adverse, local, and minor. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative 3 would result in an adverse, negligible, regional contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, regional, adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see Chapter 3). The combined NO_x and VOC emissions would have an adverse, negligible, regional contribution to these elevated exposures.

Mitigation of Effects. Air quality mitigation actions would be common to all alternatives, including the Lees Ferry alternatives, and are listed beginning on page 302.

Cumulative Effects. As described in Chapter 3 and for the Lees Ferry alternatives, road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions of PM_{10} from recreational use of the Colorado River under Alternative 3 would result in a negligible (1%) contribution to air pollution produced in the Grand Canyon, while VOC emissions contribute 5%. All other pollutants would make a significant (10%–25%) contribution. The Lower Gorge meets national standards for air quality (attainment or unclassified), but nearby

Clark County is classified nonattainment for CO, PM_{10}, and perhaps ozone. River-related emissions do not drive these elevated concentrations, but transport of this polluted air into the Lower Gorge exacerbates the adverse effects of river-related emissions on human health, visibility, and ozone exposure. The most serious cumulative human health concerns result from CO levels, to which reductions under Alternative 3 would result in a negligible, beneficial impact to adverse, regional, and moderate impacts. Cumulatively, the effects of Alternative 3, when combined with these other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 3 would make a beneficial, negligible contribution to these cumulative effects.

Conclusion. Impacts of the VOCs, SO_2, PM_{10} and NO_x produced by recreational use of the Colorado River under Alternative 3 would have negligible, adverse, regional impacts on human health, and negligible to minor, adverse, regional and local impacts on air quality related resources. Reduced emissions of CO would be moderate, and ambient levels in the region indicate moderate, regional, adverse impacts to human health. Park vegetation would continue to experience major, regional, adverse impacts from ozone exposure, and visibility would continue to be moderately, regionally degraded, and emissions from Alternative 3 make a negligible, regional and local, adverse contribution to these impacts.

In summary, Alternative 3 would make beneficial, negligible, regional reductions to adverse, negligible to moderate, regional impacts on human health from CO, and adverse, negligible, increased contributions to major, local to regional impacts on air quality related resources (plant ozone exposure, visibility). Alternative 3 would not result in the impairment of air quality and related resources in Grand Canyon National Park. Cumulatively, the effects of Alternative 3, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 3 would make a beneficial, negligible contribution to these cumulative effects.

Alternative 4 (NPS Preferred Alternative)

Analysis. Under Alternative 4, HRR trips (both day and overnight) are redistributed through the year. Pontoon tours are capped at levels slightly below current use. Helicopter shuttles would continue to operate near Quartermaster. Jetboats are used for commercial pick-ups, but not for tours. In general, emissions under Alternative 4 would be slightly lower than current conditions, as outlined in Table 4-19.

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons per year, making their impacts on human health negligible. CO emissions would be moderate (between 100 and 250 tons per year). Levels of CO measured in the eastern section of the park are very low, while those measured in the Las Vegas metropolitan area are substantially higher (see Chapter 3). Although Clark County is designated nonattainment for CO (meaning it does not meet the national standards), all monitoring stations in the county reported levels less than 80% of the national ambient air quality standards for CO from 2001 to 2003 (U.S. EPA 2004). Consequently, reduced CO emissions under Alternative 4 should not cause CO in the Lower Gorge to exceed national standards, and impacts to human health would remain adverse, regional, and moderate. Combined emissions of VOCs and NO_x would be less than 50

TABLE 4-19: ALTERNATIVE 4 EMISSIONS
TONS / YEAR

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	20,445	8.02	175.73	13.69	0.31	0.00
Aircraft	18,389	1.89	12.78	1.81	0.00	0.22
Campfires		1.00	1.10	0.01	0.15	0.00
Total	**38,834**	**10.91**	**189.62**	**15.51**	**0.46**	**0.22**
Percentage of Park Total		5.63%	19.68%	15.24%	0.78%	7.18%
Change from Alternative 1						
Alternative		-12%	-8%	-24%	-7%	-44%
Total Park		-1%	-2%	-5%	0%	-5%

tons per year, and thus at the negligible impact level for ozone-producing emissions. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard. Clark County was designated nonattainment for ozone under the 8-hour standard, but has requested a deferral of that designation until September 2004. Although river-related emissions contribute to ozone production, their reduced contributions under this alternative would be beneficial and negligible, and they would not be expected to change the park's attainment status for ozone. Impacts to human health from ozone would be adverse, regional, and moderate.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons a year, making their adverse impacts on air quality related values generally negligible. Exhaust odors and plumes may occur under calm weather conditions at attraction sites, particularly near Quartermaster. Fuel odors associated with helicopter traffic would be reduced compared with Alternative 1, since helicopter use would be roughly cut in half. Localized campfire plumes and odors dissipate quickly and are generally not considered objectionable. These impacts are adverse, local, and minor. Visibility within the park is usually below natural levels, indicating moderate regional impacts, but the small reduction in PM_{10} emitted under Alternative 4 would result in a beneficial, regional, negligible contribution to adverse, regional, moderate visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially major, regional, adverse impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see Chapter 3). The low combined NO_x and VOC emissions would result in a negligible adverse contribution to these elevated exposures.

Mitigation of Effects. Air quality mitigation actions would be common to all alternatives, including the Lees Ferry alternatives, and are listed beginning on page 302.

Cumulative Effects. As described in Chapter 3 and for the Lees Ferry alternatives, road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Emissions of PM_{10} from recreational use of the Colorado River under Alternative 4 would result in a negligible (below 1%) contribution to air pollution produced in Grand Canyon. Emissions of VOCs, NO_x, and SO_2 would be lower than current Lower Gorge emissions by 12%–44%, and they would make smaller (5%–15%) contributions to total park emissions. Emissions of CO would drop 20% but would remain at the moderate level for this pollutant. The Lower Gorge meets national standards for air quality (attainment or unclassified), but nearby Clark County is

classified nonattainment for CO, PM_{10}, and perhaps ozone. River-related emissions do not drive these elevated concentrations (Grand Canyon is almost always downwind of Clark County). However, transport of this polluted air into the Lower Gorge exacerbates the adverse effects of river-related emissions on human health, visibility, and ozone exposure. The most serious cumulative human health concerns would result from CO and ozone levels, which under Alternative 4 would remain adverse, regional, and moderate, despite the beneficial reduction in emissions compared to Alternative 1. Cumulatively, the effects of Alternative 4, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 4 would make a beneficial, negligible contribution to these cumulative effects.

Conclusion. Impacts of the VOCs, SO_2, PM_{10} and NO_x produced by recreational use of the Colorado River under Alternative 4 would have adverse, regional, negligible impacts on human health, and adverse, regional, negligible to minor impacts on air quality related resources. Reduced emissions of CO under this alternative would continue to be moderate, and ambient levels in the region indicate adverse, regional, moderate impacts to human health. Park vegetation would continue to experience adverse, regional, major impacts from ozone exposure, and visibility would continue to be moderately regionally degraded, but emission reductions under Alternative 4 would make beneficial, negligible, regional and local reductions in these impacts.

In summary, Alternative 4 would make beneficial reductions to adverse, regional, moderate effects on human health from CO and ozone, and beneficial, negligible reductions in contributions to adverse, regional, major effects on air quality related resources (visibility and plant ozone exposure). Alternative 4 would not result in the impairment of air quality and related resources in Grand Canyon National Park. Cumulatively, the effects of Alternative 4, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 4 would make a beneficial, negligible contribution to these cumulative effects.

Alternative 5 (Hualapai Tribe Proposed Action)

Analysis. Alternative 5 is the same as Alternative 4 except for actions at and downstream of the Quartermaster area (e.g., pontoon boat operations and associated helicopter operations, and upriver travel from Lake Mead). Alternative 5 includes a substantial increase in pontoon tours. However, jetboat use would not be allowed. Overall emissions expected under Alternative 5 reflect the increase in aircraft emissions but show a decline in watercraft emissions compared with current conditions (Alternative 1). These projected emissions, and their relationship to total park emissions, are presented in Table 4-20.

Human Health Impacts from Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons per year, making their impacts on human health negligible. CO emissions would be moderate, slightly less than 250 tons per year. Levels of CO measured in the eastern section of the park are very low, while those measured in the Las Vegas metropolitan area are substantially higher (see Chapter 3). Although Clark County is designated nonattainment for CO (meaning it does not meet the national standards), all monitoring stations in the county reported

TABLE 4-20: ALTERNATIVE 5 EMISSIONS
TONS / YEAR

	Launches	VOC	CO	NO_x	PM_{10}	SO_2
Watercraft	14,713	7.52	170.28	3.65	0.01	0.00
Aircraft	77,519	7.97	53.89	7.63	0.00	0.92
Campfires		1.00	1.10	0.01	0.15	0.00
Total	**92,232**	**16.48**	**225.27**	**11.29**	**0.16**	**0.93**
Percentage of Park Total		8.27%	22.55%	11.58%	0.28%	24.47%
Change from Alternative 1						
Alternative		33%	9%	-45%	-67%	133%
Total Park		2%	2%	-9%	-1%	16%

levels less than 80% of the national ambient air quality standards for CO from 2001 to 2003 (U.S. EPA 2004). Alternative 5 would result in higher CO emissions than current operations, but its implementation should not cause CO in the Lower Gorge to exceed national standards, although impacts to human health would remain adverse, regional, and moderate. Combined emissions of VOCs and NO_x would be less than 50 tons per year, and thus at the negligible impact level for ozone-producing emissions. Current ozone concentrations in the park are greater than 80% of the 8-hour ozone standard. Clark County was designated nonattainment for ozone under the 8-hour standard, but has requested a deferral of that designation until September 2004. Although river-related emissions contribute to ozone production, their combined reduced contribution under this alternative would be beneficial and negligible, and they would not be expected to change the park's attainment status for ozone. Impacts to human health from ozone would remain adverse and moderate.

Air Quality Related Values Impacted by Airborne Pollutants — Emissions of all pollutants except CO would be less than 50 tons a year, making their adverse impacts on air quality related values generally negligible. Exhaust odors and plumes may occur under calm weather conditions at attraction sites, particularly near Quartermaster. Fuel odors associated with helicopter traffic would be much greater than under Alternative 1, since helicopter use would be more than doubled. Localized campfire plumes and odors dissipate quickly, and they are generally not considered objectionable. These impacts would be adverse, local, and minor. Visibility within the park is usually below natural levels, indicating moderate impacts, but the small amount of PM_{10} emitted under Alternative 5 would result in an adverse, regional, negligible contribution to visibility problems. Ozone exposure statistics for the park are well above 25 ppm/hr, which indicates a potentially adverse, regional, major impact on plants. Nearly all ozone in the park is the result of emissions upwind of the park (see Chapter 3). The low combined NO_x and VOC emissions would make an adverse, negligible contribution to these elevated exposures.

Mitigation of Effects. Air quality mitigation actions would be common to all alternatives, including the Lees Ferry alternatives, and are listed beginning on page 302.

Cumulative Effects. As described in Chapter 3 and for the Lees Ferry alternatives, road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

Despite a large percentage reduction in PM_{10} emissions from recreational use of the Colorado River under Alternative 5, overall park production would remain essentially unchanged.

Combined emissions of VOCs and NO_x would be negligibly lower than current Lower Gorge emissions and would result in a smaller contribution to total park emissions. The relative percentage of SO_2 emitted under Alternative 5 would increase dramatically due to increased helicopter traffic. However, the actual amount emitted would remain low (the Grand Canyon area sources produce very little SO_2, magnifying small amount changes into large percentages). Parkwide emissions of CO would increase slightly, as increases in helicopter emissions would be largely offset by the elimination of jetboat traffic. The Lower Gorge meets national standards for air quality (attainment or unclassified), but nearby Clark County is classified nonattainment for CO, PM_{10}, and perhaps ozone. River-related emissions do not drive these elevated concentrations (Grand Canyon is almost always downwind of Clark County). However, transport of this polluted air into the Lower Gorge exacerbates the adverse effects of river-related emissions on human health, visibility, and ozone exposure. The most serious cumulative human health concerns result from CO and ozone levels, which under Alternative 5 would remain adverse, regional, and moderate, despite the negligible changes in CO, NO_x and VOC emissions compared to Alternative 1. Cumulatively, the effects of Alternative 5, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 5 would make a beneficial, negligible contribution to these cumulative effects by reducing most emissions.

Conclusion. Air quality impacts of recreational use of the Colorado River under Alternative 5 would make negligible, regional, adverse contributions to moderate, regional, adverse impacts on human health from CO. Emission reductions would make beneficial, regional and local, negligible contributions to adverse, regional, moderate impacts on air quality related resources (visibility and plant ozone exposure). Reduced CO emissions under this alternative would continue to be classed as moderate, and ambient levels in the region indicate adverse, regional, moderate impacts to human health. Park vegetation would continue to experience adverse, regional, major impacts from ozone exposure, and visibility would continue to be moderately degraded, but emission reductions under Alternative 5 would make beneficial, regional, negligible reductions to these impacts.

In summary, Alternative 5 would make beneficial, negligible reductions to adverse, regional, moderate effects on human health from ozone; and adverse, local, negligible contributions to moderate regional adverse effects from CO. It would make generally beneficial, negligible reduced contributions to adverse, local to regional, major effects on air quality related resources (visibility and plant ozone exposure). Alternative 5 would not result in the impairment of air quality and related resources in Grand Canyon National Park. Cumulatively, the effects of Alternative 5, when combined with other past, present, and reasonably foreseeable actions, would continue to be adverse, regional, and moderate from ozone exposure levels and degraded visibility. Alternative 5 would make a beneficial, negligible contribution to these cumulative effects by reducing most emissions.